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Time Stretching using Phase

Generalized Estimating Equations

Highlights

Segmentation of Facial Feature

BDS/GPS Multi-System Positioning

Discovering Thoughts, Inventing Future

VOLUME 16 ISSUE 1 VERSION 1.0



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Human Face Detection and Segmentation of Facial Feature Region

By Tania Akter Setu & Dr. Md. Mijanur Rahman

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Abstract- Human face, facial feature detection and Segmentation have attracted a lot of attention because of their wide applications. In computer-human interaction, face recognition, video surveillance, security system and so many application use automatic face detection. This paper is about a study of detecting human faces within images and segmenting the face into numbered regions which are the face-, mouth-, eyes- and nose regions respectively. For face detection we have used the Viola–Jones object detection framework. Sometime the VJOD make a false frame of object detection. Here trying to detect the problem of identification and improve the detection quality by changing the threshold value. It detect the frontal face of human which is 2D. From detected face image we separate the extracted part of face in a single image and Segment nose, eyes, lip and hole face portion by Discontinuous based Image Segmentation. The development and experiments demonstration of this research is done on MATLAB 2013. The learning behavior of the algorithm was tested on different face of human.

Keywords: *face detection, viola jones object detection, feature extraction, image segmentation.*

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Human Face Detection and Segmentation of Facial Feature Region

Tania Akter Setu ^α & Dr. Md. Mijanur Rahman ^σ

Abstract- Human face, facial feature detection and Segmentation have attracted a lot of attention because of their wide applications. In computer-human interaction, face recognition, video surveillance, security system and so many application use automatic face detection. This paper is about a study of detecting human faces within images and segmenting the face into numbered regions which are the face-, mouth-, eyes- and nose regions respectively. For face detection we have used the Viola-Jones object detection framework. Sometime the VJOD make a false frame of object detection. Here trying to detect the problem of identification and improve the detection quality by changing the threshold value. It detect the frontal face of human which is 2D. From detected face image we separate the extracted part of face in a single image and Segment nose, eyes, lip and hole face portion by Discontinuous based Image Segmentation. The development and experiments demonstration of this research is done on MATLAB 2013. The learning behavior of the algorithm was tested on different face of human.

Keywords: face detection, viola jones object detection, feature extraction, image segmentation.

I. INTRODUCTION

Automated face detection is an interesting and important computer vision problem with many commercial and law enforcement applications. It is very easy for human beings but very hard to automate in computerized applications. In practice, applications of automatic face recognition include access control, video-surveillance, identity variation, etc. The problem of automating the process of human face recognition is very complex and depends on many parameters such as lighting conditions, facial expressions, positions and orientations of the human faces. Researches in automatic face recognition started in the 1960s. There has been significant progress in the recent years that includes a number of face recognition and modeling systems. The Viola-Jones object detection framework is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones.[1][2]This algorithm is implemented in OpenCV. The basic problem to be solved is to implement an algorithm for detection of faces in an image. This can be solved easily by humans. However there is a task contrast to how difficult it actually is to make a computer successfully

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solve this task. In order to easy the task Viola-Jones limit themselves to full view frontal upright faces. If we want to detect the entire face must point towards the camera and it should not be tilted to any side. A brief introduction to the foundations of face detection algorithms have discussed in this paper. For Face detection we have used viola jones algorithm and try to improve the detection changing the threshold value of image and describe the problem of detection. Face detection is a feature based approach in which face geometry is taken which includes face shape and other facial features like mouth, eyes, nose etc. The algorithm requires 2- D images whose threshold values of intensities are taken into consideration in the measurement of the number of the pixels to get the entire face feature area. We also compute the boundary box value where the detection portion are exist. From detected face image we separate the extracted part of face which are nose, eyes and lip and hole face portion by Discontinuous based Image Segmentation.

II. RELATED RESEARCHES

Researches in automatic face recognition started in the 1960s. The first attempt to automated facial recognition approach consisted of checking the measurements between different facial features such as the corners of the eyes, the hair lines, holes of nose etc. This attempt was not that much successful. Towards the end of 1980s, the eigenfaces2 techniques prompted more intense researches which were used to find a face in a photo and to compare the images of field has reached up to that point where the operational use of facial recognition on high resolution frontal image was now feasible. The Viola and Jones face detector is the first ever face detection framework to provide successful face detection in real time. It contains three main ideas that make it possible to run in real time: the integral image, classifier learning with Adaboost, and the intentional cascade structure [1]. However, it produces a high false positive rate and false negative when directly applied to the input image. Various research contributions have been made to overcome these problems, such as using pre-filtering or post-filtering methods based skin color filter to provide complementary information in color images. In [2] [3] the authors proposed an interesting method to reduce the false detection by using a skin color as a pre-filtering stage prior to the application VJFD. In [4] the

authors proposed a hybrid method to reduce false positive in the VJFD by using skin color face post-filtering method in HSV color space. To reduce the effects of lighting, the authors in [5] applied an illumination compensation algorithm in the first step and then, they combine VJFD and the skin color detector to detect face. In [13] the authors proposed a method to reduce the false positive rate and keeping the high detection rate of the VJFD in real applications. In [6] the author has been proposed an algorithm for face detection based on edge information and hue. Though the results were not accurate for all type of images. Recently, a lot of research is being done in the vision community to accurate face detector in real work application, in particular, the seminal work by viola and Jones [7]. The Viola and Jones face detector has become the de facto standard to built successful face detection in real time, however, it produces a high false positive (detecting a face when there is none) and false negative rate (not detecting a face that's present) when directly applied to the input image.

III. IMAGE SEGMENTATION

Image segmentation is one of the most essential part in digital image processing. In image segmentation, images are divided into multiple set of pixels, generally required to detect the region of interest (ROI) from an image based on some homogeneity criteria such as color, intensity or texture, which helps to locate and identify objects or boundaries in an image.

There are currently different kind of algorithm, for doing the segmentation process. Each of them are separate from each other.

Currently image segmentation approach, based on two properties of an image, is divided into two categories:

a) Discontinuities based

In this category, subdivision of images are done by the basis of suddenly changes of the intensity of grey levels of an image. Our task is primarily based on identification of isolated points, lines and edges. This include image segmentation like edge detection.

b) Similarities based

In this category, subdivision of images are done by the basis of similarities in intensity or grey levels of an images. Our task here is on determine of similar points, lines and edges. It is also includes image segmentation algorithms like thresholding, region growing, region splitting and merging.

There are different kind of method for Image segmentation and one of them is edge detection based. There are many different ways to perform edge detection, however, two most prominent used algorithm is Gradient Based Method and Gray Histogram

Technique. We have used a operator of Gradient Based Method which is sobel operator.

Gradient is the first derivative for image $f(x, y)$. In an image when there is an abrupt change in the intensity near edge[9]. Basically sobel operator, canny operator, Laplace operator, Laplacian of Gaussian (LOG) operator etc is used as operator in gradient based method. Usually canny operator is used but there are a problem. Because it takes more time as compared to sobel operator. For this reason we have used Sobel operator. The sobel operator consists of a pair of 3×3 convolution kernels map as shown in Figure 1. One kernel is simply the other rotated by 90° .

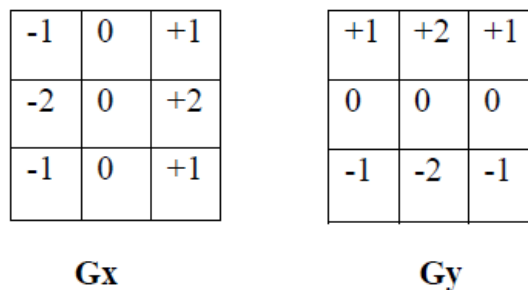


Fig. 1 : Masks used by Sobel Operator

These kernels are designed to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these Gx and Gy).

$$|G| = \sqrt{Gx^2 + Gy^2} \tag{7}$$

Typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy| \tag{8}$$

which is much faster to compute. The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by[7]:

$$\theta = \arctan(Gx/Gy) \tag{9}$$

IV. VIOLA JONES OBJECT DETECTION FRAMEWORK

The viola jones is a object detection frame work which is used to detect the human face. The main concept of the Viola-Jones algorithm is capable of detecting faces across a given input image. The viola jones performed operation in each pixel of a required area .[11].

a) Feature Selection

The Viola-Jones face detection framework work in a analyzes a given sub-window using features consisting of two or more rectangles, such as two-

rectangle features, three-rectangle features and four-rectangle features, shown in Figure-2. The simple features used Haar basis functions[12]:

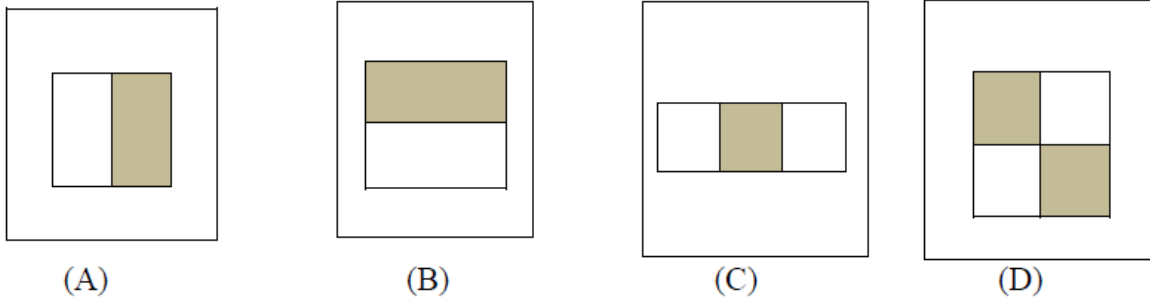


Fig. 2 : Two-rectangle features are shown in (A) and (B). Figure (C) shows a three-rectangle feature, and (D) a four-rectangle feature.

There are many different types of artificial intelligence techniques to train a classification function. The Viola-Jones method used a simple and efficient classifier which based on AdaBoost learning technique, which formulated by Freund and Schapire in [13]. If we want to get best result from this algorithm image have to in proper lighting condition include all facial properties like (skin color, glasses, facial hair). Here we first describe about the integral image.

b) Integral Image Computation

Rectangle feature of an image can be measure by using an intermediate representation for the image which we call the integral image.[4] The integral image at location x, y contains the sum of the pixels above and to the left of x, y , inclusive:

$$ii(x, y) = \sum_{x' \leq x, y' \leq y} i(x', y'), \quad (1)$$

where $ii(x, y)$ is the integral image and $i(x, y)$ is the original image (see Fig. 2). Using the following pair of recurrences

$$s(x, y) = s(x, y - 1) + i(x, y) \quad (2)$$

$$ii(x, y) = ii(x - 1, y) + s(x, y) \quad (3)$$

where $s(x, y)$ is the cumulative row sum, $s(x, -1) = 0$, and $ii(-1, y) = 0$ the integral image can be computed in one pass over the original image. Using the integral image any rectangular sum can be computed in four array references (see Fig. 3). One alternative motivation for the integral image comes from the “boxlets” work of Simard et al.[11]

Every feature calculate results come from in a single value which is calculated by subtracting the sum of the white rectangle(s) from the sum of the black rectangle(s).

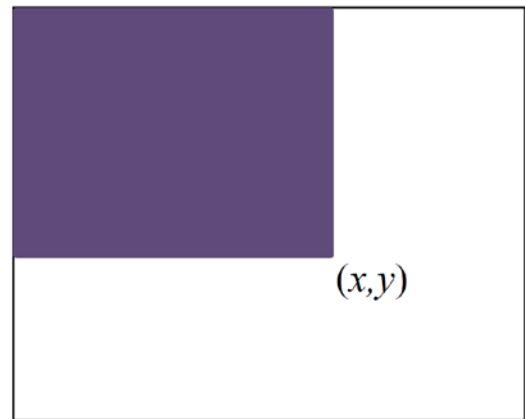


Fig. 3 : The value of the integral image at point (x, y) is the sum of all the pixels above and to the left.

The sum of the pixels within rectangle D can be computed with four array references[12]:

- The value of the integral image at location 1 is the sum of the pixels in rectangle A. The value at location 2 is $A + B$, at location 3 is $A + C$, and at location 4 is $A + B + C + D$.
- The sum within D can be computed as $4 + 1 - (2 + 3)$. A two-rectangle feature can be computed in six array references – for any scale

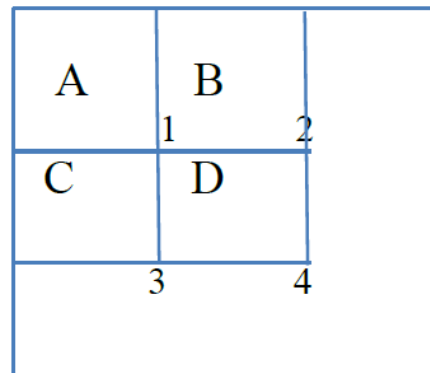


Fig. 4 : The calculation of pixel sum within a rectangle

c) *Learning Algorithm*

It is a Adaboost Training algorithm. It is a machine learning boosting algorithm. This algorithm capable of constructing a “strong” classifier though a weighted combination of a linear combination of weighted simple “weak” classifiers.

$$h(x) = \text{sign}(\sum_{j=1}^M a_j h_j(x)) \quad (4)$$

Each weak classifier is a threshold function based on the feature f_j .

$$h_j(x) = \begin{cases} -s_j, & \text{if } f_j < \theta_j \\ s_j, & \text{otherwise} \end{cases} \quad (5)$$

Where threshold is and are determine in the training, as well as the coefficients. [14]

d) *Cascade Architecture*

In general face detection algorithm based on Ada Boost may divided into three major parts[14]:

- First one “The Integral Image” to extract face’s rectangle feature,
- The second is formed weak classifier; AdaBoost trained the weak classifier with strong classifier to accurately distinguishing between face and non-face.
- The third one is in accordance with the principle of “first heavy after the light” cascade multiple strong classifier.

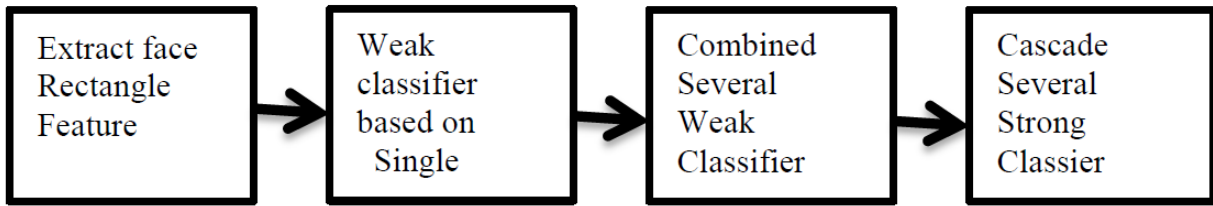


Fig. 5 : The detection based on cascade Classifiers

e) *Algorithm*

The overall *Viola-Jones* algorithm is summarized below:

Input:
A greyscale image, a scaling factor (s) and scanning factor (p)
Output:
The location and size of a detected face
Procedure:
Size = detector. Size while size _ image. height AND size _ image. width do for i from 0 to image. width-size in increments of p do for j from 0 to image. height-size in increments of p do if runCascade(subwindow of image of size size located at (i,j)) then runCascade(subwindow of image of size size located at (i,j)) then Add (s,i,j) to detection list size = RoundUp (size * s) return average of detections.

Fig. 6 : The summary of *Viola-Jones* algorithm



V. METHODOLOGY

The process for build up the propose system will be included parts:

- Face Image Acquisition:
- Smoothing/Filtering
- Features Extraction
- Image segmentation.

After performing detection it is possible to detect the human face and segment the different part of face.

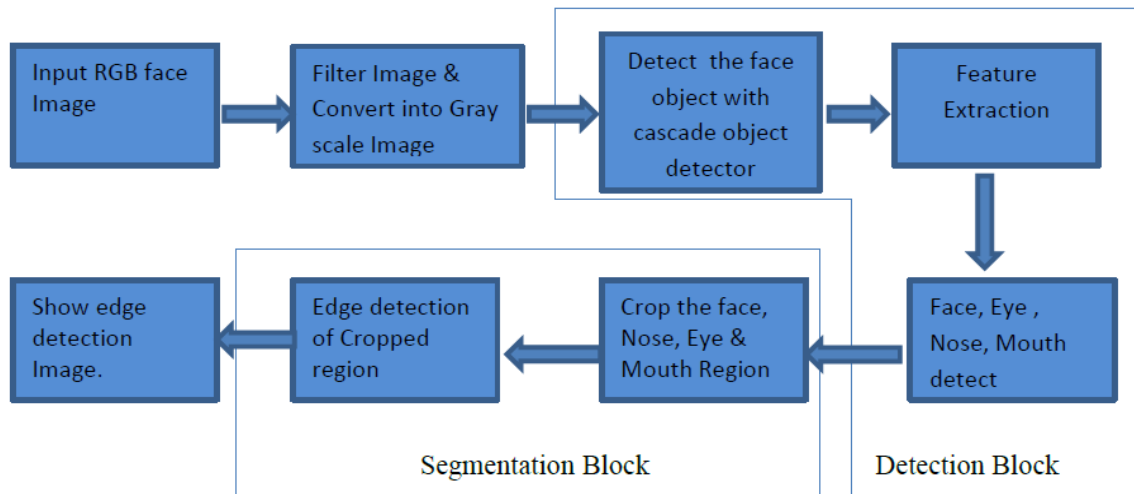


Fig. 7: Block Diagram Detection and Segmentation Process

a) Face Image Acquisition

The process of getting image from any source, especially hardware is called as image acquisition. For image acquisition we can use normally digital camera. In the image processing it is impossible without image receiving/acquisition. The sweetest Acquisition process is a digital camera into various formats such as Bitmap, JPEG, GIF and TIFF etc. We can also collect image from different kind of we page.

b) Smoothing/Filtering

The purpose of smoothing is to reduce noise and improve the visual quality of the image often; smoothing is referred to as filtering. For this purpose of filtering we have used Gaussian Filtering Techniques. The Gaussian function are given below:

$$G_{\sigma}(x, y) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \quad (6)$$

If the image is not noisy it is not necessary to filtering. Because filtering is not suitable for every image. We have use filtering for better result if necessary.

c) Features Extraction

It is obvious that feature is very significant to any object detection algorithm. In matlab 2013 have used computer vision object detector tool box. For feature selecting here used the viola jones algorithm. Basically, there are a lot of features, such as eyes, nose, the topology of eye and nose, can be used for face detection. In viola jones face detection, a very simple and straightforward feature has been used. Each feature can be obtained by subtracting white areas from the

black areas. Here, the area means the summation of all the pixels' gray value within the rectangle. Aiming at calculating these features, a special representation named as integral image has been used. First I have detect the face then other parts of the face. If it cannot extract the face It will not find the any part of feature of face. It also compute the boundary box value which performs multi-scale object detection on the input image and return M-by-4 matrix.

d) Segmentation

In our research Image segmentation dividing human face image into multiple parts. This is typically used to identify objects or other relevant information in digital images. From detected face image we separate the extracted part of face which are nose, eyes and lip and hole face portion by Discontinuous based Image Segmentation which is Edge detection. The segmentation of image using edge detection convert in a binary image. For image segmentation and edge detection we have used sobel operator of Gradient Based Method.

VI. EXPERIMENTS AND EXPERIMENTAL RESULTS

All the methods, techniques and algorithms have implemented using open CV in Matlab. It is enriched with many toolbox which make our research very smooth and easy. For object detection we have vision cascades object detector toolbox which embedded with Matlab 2013. First we read an image by imread () function. Then crop the image by imcrop () function. Then convert the RGB image into the gray

scale image. Then use the vision.Cascade Object Detector () function to detect the face. when the human face detect then we use different color box to mention different part of the face. The boundary box of Red indicate the face, green indicate the eyes and blue indicate the nose, yellow indicates the lip. It also provide the boundary box value of detected face, nose, lip, eye area. BBOXES performs multi-scale object detection on the input image, I, and return an M-by-4 matrix defining M bounding boxes containing the detected objects.

Each row in BBOXES is a four-element vector, [x y width height], that specifies the upper left corner and size of a bounding box in pixels. When no objects are detected, BBOXES is empty. I must be a grayscale or truecolor (RGB) image. We segment the different part of face by cropping and show in the different window. Edge Detection of Face, Eyes, Lip and Nose using Sobel operator.



Fig. 8 : Original image



Fig. 9 : Cropped Gaussian filter Gray scale image

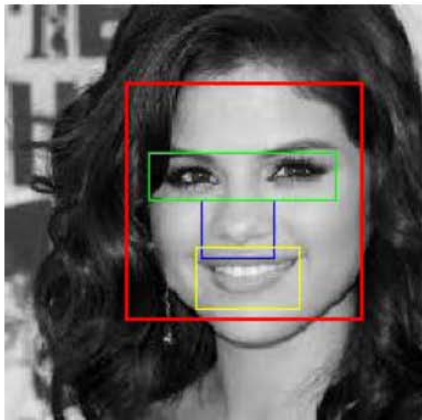


Fig. 10 : Detection of face and other part colored boundary box. Eyes & Mouth

BBOXES	X	Y	Width	Height
Face	61	40	116	116
Nose	98	97	35	29
Mouth	95	120	51	31
Eyes	72	74	92	23

Table 1 : Boundary Box value Detected Face, Nose by

After detection crop the face, Eyes, Nose & Mouth Portion and then perform Segmentation. Edge Detection of Face, Eyes, Lip and Nose using Sobel Operator.



Fig. 11 : Crop and Edge Detection of Face

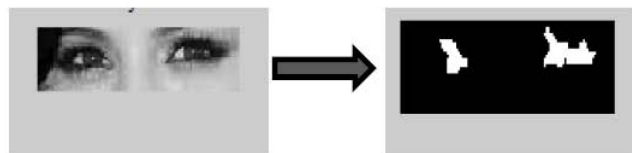


Fig. 12 : Crop and Edge Detection of Eyes

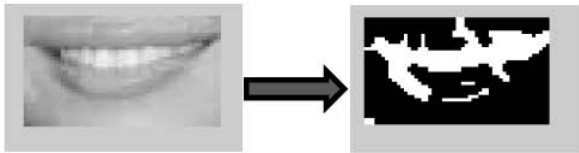


Fig. 13 : Crop and Edge Detection of Mouth

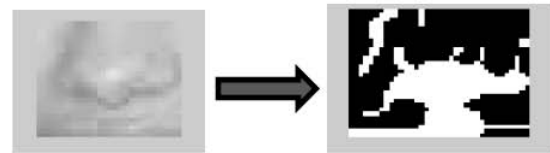


Fig. 14 : Crop and Edge Detection of Nose

There are some problem in detection using *Viola-Jones* algorithm which embedded in open CV toolbox. It detect which have a face in the center of image. It is bounded by some fact. It have a model map, out of this it cannot detect other parts of face and body.

If a face is include with large background and face position is corner of the image then it cannot detect correctly. Another problem is side view of face image cannot detect.

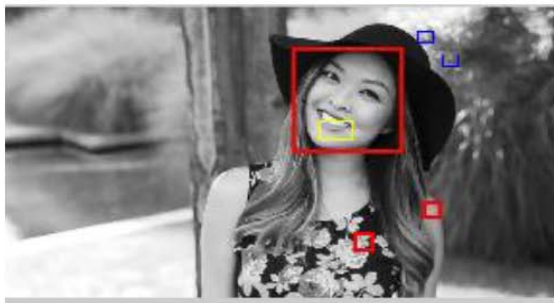


Fig. 15 : Incorrect Detection of face, nose, eyes, mouth.



Fig. 16 : Side view of image where face not detect

In figure 15 face has found 3, nose found 2 and one mouth. But it's detection is incorrect. In figure 16 shows a side view of face image. In this case it doesn't found any face.

on Computer Vision (Book) by Cha Zhang, et al. 2010.

VII. CONCLUSION

In our task we trying to improve the face detection using *viola john* algorithm and segment the part of face like eyes, nose, lip etc. Then make the edge detection to convert image into binary image which can use in various purpose in image processing field .In our research we only work with the frontal face of human. If we use side view of image it cannot detect correctly. In future we will try to detect the face from various orientation, angle, geometric view and we want make classification of human face base on this information we extracted from this work. We will try to classify face expression based on segmentation of lip and mouth region. We think it will be very efficient for classification and detection.

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BDS/GPS Multi-System Positioning based on Nonlinear Filter Algorithm

By JaeHyok Kong, Xuchu Mao & Shaoyuan Li

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Abstract- The Global Navigation Satellite System can provide all-day three-dimensional position and speed information. Currently, only using the single navigation system cannot satisfy the requirements of the system's reliability and integrity. In order to improve the reliability and stability of the satellite navigation system, the positioning method by BDS and GPS navigation system is presented, the measurement model and the state model are described. Furthermore, Unscented Kalman Filter (UKF) is employed in GPS and BDS conditions, and analysis of single system/multi-systems' positioning has been carried out respectively. The experimental results are compared with the estimation results, which are obtained by the iterative least square method and the extended Kalman filtering (EFK) method. It shows that the proposed method performed high-precise positioning. Especially when the number of satellites is not adequate enough, the proposed method can combine BDS and GPS systems to carry out a higher positioning precision.

Keywords: global navigation satellite system (GNSS), positioning algorithm, unscented kalman filter (UKF), beidou navigation system (BDS).

GJCST-G Classification : G.1.5, G.1.6, G.2.1



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BDS/GPS Multi-System Positioning based on Nonlinear Filter Algorithm

JaeHyok Kong ^α, Xuchu Mao ^σ & Shaoyuan Li ^ρ

Abstract- The Global Navigation Satellite System can provide all-day three-dimensional position and speed information. Currently, only using the single navigation system cannot satisfy the requirements of the system's reliability and integrity. In order to improve the reliability and stability of the satellite navigation system, the positioning method by BDS and GPS navigation system is presented, the measurement model and the state model are described. Furthermore, Unscented Kalman Filter (UKF) is employed in GPS and BDS conditions, and analysis of single system/multi-systems' positioning has been carried out respectively. The experimental results are compared with the estimation results, which are obtained by the iterative least square method and the extended Kalman filtering (EKF) method. It shows that the proposed method performed high-precise positioning. Especially when the number of satellites is not adequate enough, the proposed method can combine BDS and GPS systems to carry out a higher positioning precision.

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I. INTRODUCTION

With the development of space information technology, some countries are constructing Global Navigation Satellite System (GNSS). Now, in addition to USA's GPS and Russia's GLONASS, the Europe's Galileo and China's Bei Dou navigation satellite System (BDS) are being built. Japan, India and other countries are also planning to build their own regional navigation satellite systems. Even though it is GPS that is the most developed navigation satellite system and it has many advantages, it also has some disadvantages of system reliability that cannot satisfy the requirements of a single navigation system in the certain situations [1]. Recently, the idea of multi-navigation positioning that consists of GPS, GLONASS, Galileo and regional satellite positioning system is gradually getting more interest in the field of satellite navigation. Especially, the combination of GPS and BDS can overcome the deficiency of the single system, and shows better effects on system performance.

The most conventional positioning estimation methods are the iterative least square method (ILS), extended Kalman filter (EKF) and unscented Kalman filter (UKF), etc. ILS can solve three-dimensional

positioning only when it receives the signals from at least four satellites. This method is simple, and its computing speed is fast, but it has a large linearization error and a low positioning estimation precision. The EKF can only be accurate for a first order Taylor series. There may be a larger nonlinear error, and it needs to compute the Jacobian matrix, in addition to the calculation being difficult and one of the main sources of error [2]. The UKF represents statistical properties of the system by deterministic sampling and avoids the disadvantage that the EKF must compute the Jacobian matrix. Theory shows that the EKF predicts the means correctly up to the second order of Taylor series and covariances up to fourth order. In contrast, the UKF predicts the means and covariances correctly up to the fourth order [3].

The positioning accuracy of the GNSS, especially the low-price GNSS receiver, cannot always be satisfied. This is because during the positioning process many errors, especially the measurement and satellite position errors, cannot be deleted. Traditional methods can hardly minimize their influence. Filtering algorithm provides an important method to reduce these errors and improve the GNSS positioning precision.

This paper proposes a BDS-GPS system model, using UKF to perform position estimation, and the experimental results illustrate the effectiveness of our proposed method.

Section II lists the general concept of the GNSS positioning. Section III summarizes the general used algorithm for GNSS receiver positioning and introduces the UKF algorithm which will be used in our proposed models for GNSS position estimation. Section IV describes the unity of space coordinate system and time system of GPS and BDS. Section V addresses the developed nonlinear model and the filter implementation. Section VI includes recent experimental results and provides the comparison of these results from GPS and BDS with ILS, EKF and UKF. Finally, Section VI concludes the paper and describes the future developments.

II. GNSS POSITIONING OVERVIEW

GNSS is a worldwide, all-weather navigation systems able to provide tridimensional position, velocity, and time synchronization to UTC scale. GNSS considers the earth's center as the reference point, to determine the position of the receiver antenna in the reference

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coordinate system. Since the positioning operation requires only one receiver, it is called the standalone positioning. The basic principle of the standalone GNSS positioning is that taking the observed distance between GNSS satellite and the user receiver antenna as the benchmark, which is based on the known instantaneous satellites' coordinates, to determine the position of the corresponding user receiver antenna. According to the different positions of the user receiver antennas, GNSS positioning can be divided into dynamic positioning and static positioning.

GNSS positioning is based on the one-way ranging technique: the propagation time to transmit from satellite to user receiver is measured and multiplied by the signal propagation velocity to obtain satellite-to-user range. The offset of the receiver clock relative to the system time scale should be estimated to position. The measured range between receiver and satellite is referred to as pseudorange, and can be represented as follows:

$$\rho_i = R_i + c\delta t_u + \varepsilon_i \tag{1}$$

where ρ_i is the i th satellite's pseudorange measurement, R_i is the geometric distance receiver-satellite, $c\delta t_u$ is the receiver clock offset (scaled by speed of light c) and ε_i contains the residual errors after satellite-based and atmospheric error corrections.

Equation (1) holds for both single GNSS (i.e. BDS or GPS only) and $c\delta t_u$ is referred to the time scale of the considered system. In multi-constellation case, a further unknown, representing the inter-system time offset, must be estimated.

III. GNSS POSITIONING ALGORITHM

a) Iterative Least Square Method

ILS based position estimation is conventionally used by GNSS receiver because of its simplicity and rapidity. The algorithm is based on the pseudorange equation. Since the pseudorange equation contains four unknowns: 3-D coordinates and one clock bias, at least four satellites are received to take 3-D positioning. Since these equations are nonlinear, they need to be linearized using the first order Taylor series approximation. Then a least squares solution is used and the receiver position can be calculated out [4]. This algorithm is simple and easy to implement, but the position estimation accuracy is low and the stability is not strong.

b) Unscented Kalman Filtering

UKF algorithm is the minimum variance estimation based on UT (Unscented Transform). It was first proposed by Julier et al. [5] in 1995. In the UKF with the deterministic samplings, the state distribution is again approximated by Gaussian Random Variables

(GRV), but it is now represented using a minimal set of carefully chosen points. Those points are propagated through the true nonlinear system. Besides the possibility of improvement in precision, the UKF is much easier to implement than EKF. Unlike EKF, the UKF do not require Jacobian evaluations or any partial derivative calculation. Some papers were proposed the new UKF algorithm [6], and used in GPS positioning [7,8,9]. When no more than 4 satellites can be received, a precision of data processing can be obtained by considering UKF algorithm's small linearization error. Based on this fact, this paper proposes UKF as the position estimation algorithm for composing GNSS based navigation systems.

First, assume that state and measurement equations of the system are discrete time nonlinear systems:

$$\begin{cases} x_{t+1} = f(x_t, w_t) \\ z_t = h(x_t) + v_t \end{cases} \tag{2}$$

where x_t is state vector, z_t is measurement vector, and w_t is zero-mean independent gaussian white noise of which the covariance matrix is Q . v_t is zero-mean independent gaussian white noise of the measurement of which the covariance matrix is R .

Details about the UKF algorithm are described as follows:

Initialize with

$$\begin{aligned} \hat{x}_0 &= E[x_0] \\ P_0 &= E[(x_0 - \hat{x}_0)(x_0 - \hat{x}_0)^T] \\ \hat{x}_0^a &= E[x^a] = [x_0^T \quad 0 \quad 0]^T \\ P_0^a &= E[(x_0^a - \hat{x}_0^a)(x_0^a - \hat{x}_0^a)^T] = \text{diag}(P_0, Q, R) \end{aligned} \tag{3}$$

Calculate the sigma point

$$\chi_{i-1}^a = \begin{bmatrix} \hat{x}_{i-1}^a & x_{i-1}^a \pm \sqrt{(L + \lambda)P_{i-1}^a} \end{bmatrix} \tag{4}$$

Calculate weight coefficient

$$\begin{aligned} W_0^{(m)} &= \lambda / (L + \lambda) & W_0^{(c)} &= \lambda / (L + \lambda) + (1 - \xi^2 + \eta) \\ W_i^{(m)} &= W_i^{(c)} = 1 / [2(L + \lambda)] & i &= 1, \dots, 2L \end{aligned} \tag{5}$$

where $\lambda = \xi^2(L + k) - L$, $0 \leq \xi \leq 1/2$, in order to control the distribution of the sigma points; $\eta = 2$, in order to introduce the high order information.

Time update:

$$\begin{aligned} \chi_{t|t-1}^x &= f(\chi_{t-1}^x, \chi_t^w) \\ \hat{\chi}_{t|t-1} &= \sum_{i=0}^{2L} W_i^{(m)} \chi_{i,t|t-1}^x \\ P_{t|t-1} &= \sum_{i=0}^{2L} W_i^{(c)} [\chi_{i,t|t-1}^x - \hat{\chi}_{t|t-1}^x][\chi_{i,t|t-1}^x - \hat{\chi}_{t|t-1}^x]^T \\ z_{t|t-1} &= h(\chi_{t-1}^x, \chi_t^v) \\ \hat{z}_{t|t-1}^- &= \sum_{i=0}^{2L} W_i^{(m)} z_{i,t|t-1} \end{aligned} \quad (6)$$

Measurement update equations:

$$\begin{aligned} P_{z_t, z_t} &= \sum_{i=0}^{2L} W_i^{(c)} [z_{i,t|t-1} - \hat{z}_{t|t-1}^-][z_{i,t|t-1} - \hat{z}_{t|t-1}^-]^T \\ P_{x_t, z_t} &= \sum_{i=0}^{2L} W_i^{(c)} [\chi_{i,t|t-1}^x - \hat{\chi}_{t|t-1}^-][z_{i,t|t-1} - \hat{z}_{t|t-1}^-]^T \\ K_t &= P_{x_t, z_t} P_{z_t, z_t}^{-1} \\ \hat{\chi}_t^x &= \hat{\chi}_{t|t-1}^- + K_t (z_t - \hat{z}_{t|t-1}^-) \\ P_t &= P_{t|t-1} - K_t P_{z_t, z_t} K_t^T \end{aligned} \quad (7)$$

where,

$$x^a = [x^T \quad w^T \quad v^T]^T; \quad \chi^a = [(\chi^x)^T \quad (\chi^w)^T \quad (\chi^v)^T]^T$$

IV. THE UNITY OF TIME AND SPACE SYSTEM OF BDS AND GPS

a) The unity of the two coordinate systems

The definition of coordinate system of BDS's CGCS2000 is essentially equal to GPS's WGS84. Their reference ellipsoids are very similar, and there mainly exists an extremely small flat rate difference. Flat rate difference between two coordinate systems causes a deviation of 0.105mm in latitude and altitude, and the largest deviation of gravity is $0.016 \times 10^{-8} m/s^2$. In the current level of the accuracy of measurement, such deviation can be neglected. So we can directly use the position data GPS and BDS without coordinate transformation.

b) The unity of the two time systems

Since BDS and GPS use atomic time, there is no leap second in both systems. The difference between the two systems is 1356 weeks in whole week and 14 seconds in second. The navigation message of BDS contains the synchronization parameters between BDS and GPS, but its implementation content in the message is unpublished. So we cannot directly realize the full synchronization between the two systems. Instead this problem, we simply add 14 seconds to BDT's time for the rough calculation, and add a variable to represent the different system's time deviation.

V. THE POSITIONING OF BDS AND GPS USING THE UKF

Nonlinear Kalman filter can be well applied in the GNSS positioning estimation, because of the characteristics of the Kalman filter in which the current state parameter is updated according to the observed value using the predictive value. The system model consists of the process model and the measurement model.

a) Process model

The state includes the receiver position and velocity coordinates in CGCS2000 ECEF coordinate system, and the receiver clock offset which is related to states and the clock drift caused by the Doppler deviation. It also includes the non-white error in each satellite channel. So the overall system state has 10 fundamental states plus one shaping state for each observable channel:

$$x_t = (X_t, \dot{X}_t, Y_t, \dot{Y}_t, Z_t, \dot{Z}_t, c\delta t_t, c\dot{\delta}t_t, c\delta t_t^{sys}, \delta R, \epsilon_{1t}, \epsilon_{2t}, \dots, \epsilon_{nt})^T$$

where, (X_t, Y_t, Z_t) is the receiver's position, $(\dot{X}_t, \dot{Y}_t, \dot{Z}_t)$ is the receiver velocity, $c\delta t_t, c\dot{\delta}t_t$ are the receiver clock offset and the clock drift bias, respectively, $c\delta t_t^{sys}$ is the offset between the two systems, δR is the offset between the Doppler shift and pseudorange's rate, $(\epsilon_{1t}, \epsilon_{2t}, \dots, \epsilon_{nt})$ is the non-white error in each satellite channel. Because the error in each satellite is independent, it can be modeled as a first-order Gaussian-Markov process.

Since there is a deviation in the two systems' times, in order to eliminate positioning error caused by time deviation between BDS and GPS, a variable $c\delta t_t^{sys}$ should be added.

Considering the above state model, and a generic kinematics model for the receiver coordinates, we obtain the associated system model.

$$x_{t+1} = F \cdot x_t + C \cdot w_t$$

The state transition matrix F is given by

$$F = \begin{pmatrix} A & 0 \\ 0 & B \end{pmatrix}$$

where A is a 10×10 time invariant matrix and B is a $n \times n$ diagonal matrix, which are given respectively by

$$A = \begin{pmatrix} 1 & T & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & T & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & T & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & T & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$B = \text{diag}(\alpha, \alpha, \dots, \alpha)$$

w_t is the system driving noise, which is given by

$$w_t = [\delta\ddot{X}_t, \delta\ddot{Y}_t, \delta\ddot{Z}_t, w_{1t}, w_{2t}, w_{\text{sys}}, w_{\delta R}, w_{c1t}, w_{c2t}, \dots, w_{cnt}]^T$$

where, $\delta\ddot{X}_t$, $\delta\ddot{Y}_t$ and $\delta\ddot{Z}_t$ are noises due to models' receiver acceleration and other system disturbances, w_{ci} is the driving noise of the i th shaping filters of the channel, w_{1t} and w_{2t} are the clock offset model driving noises, w_{sys} is noise of the δt^{sys} , and $w_{\delta R}$ is noise of the δR . These noises are assumed to be zero-mean and uncorrelated white random sequences.

The noise matrix C is given by

$$C = \begin{pmatrix} D & 0 \\ 0 & E \end{pmatrix}$$

where, D is a 10×7 time invariant matrix and E is a $n \times n$ diagonal matrix which are given respectively by

$$D = \begin{pmatrix} T^2/2 & 0 & 0 & 0 & 0 & 0 & 0 \\ T & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & T^2/2 & 0 & 0 & 0 & 0 & 0 \\ 0 & T & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & T^2/2 & 0 & 0 & 0 & 0 \\ 0 & 0 & T & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & c & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & c & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$E = \text{diag}(\beta, \beta, \dots, \beta)$$

The correspondent process noise covariance matrix Q_t is given by

$$Q_t = E\{w_t w_t^T\} = \begin{pmatrix} Q_{\delta\ddot{X}\ddot{Y}\ddot{Z}} & 0 & 0 & 0 & 0 \\ 0 & Q_{\delta t} & 0 & 0 & 0 \\ 0 & 0 & \sigma_{\delta\text{sys}}^2 & 0 & 0 \\ 0 & 0 & 0 & \sigma_{\delta R}^2 & 0 \\ 0 & 0 & 0 & 0 & Q_{ct} \end{pmatrix}$$

with

$$Q_{\delta\ddot{X}\ddot{Y}\ddot{Z}} = \text{diag}(\sigma_{\ddot{X}}^2, \sigma_{\ddot{Y}}^2, \sigma_{\ddot{Z}}^2)$$

$$Q_{ct} = \text{diag}(\sigma_{c1}^2, \sigma_{c2}^2, \dots, \sigma_{cn}^2)$$

where $\sigma_{\delta\text{sys}}^2$ is the variance associated with the δt^{sys} , $\sigma_{\delta R}^2$ is the variance associated with the δR , $\sigma_{\ddot{X}}^2$, $\sigma_{\ddot{Y}}^2$ and $\sigma_{\ddot{Z}}^2$ are the process noise variances associated with $\delta\ddot{X}_t$, $\delta\ddot{Y}_t$ and $\delta\ddot{Z}_t$, $\sigma_{c1}^2, \sigma_{c2}^2, \dots, \sigma_{cn}^2$ are the variances associated with the shaping filters driving noises and, $Q_{\delta t}$ is defined by following equations.

$$Q_{\delta t} = E\{w_{\delta t} w_{\delta t}^T\} = \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix}$$

$$Q_{11} = \frac{h_0}{2}T + 2h_{-1}T^2 + \frac{2}{3}\pi^2 h_{-2}T^3$$

with

$$Q_{12} = 2h_{-1}T + \pi^2 h_{-2}T^2$$

$$Q_{22} = \frac{h_0}{2T}T + 2h_{-1} + \frac{8}{3}\pi^2 h_{-2}T$$

where

$$\alpha = \frac{2\tau-1}{2\tau+1}, \beta = \frac{2\tau}{2\tau+1} \quad \tau=100$$

$$h_0 = 9.4 \times 10^{-20}, h_{-1} = 1.8 \times 10^{-19}, h_{-2} = 3.8 \times 10^{-21}$$

b) Measurement model

The pseudoranges and Doppler shifts form the measurements set, the measurement equations of the BDS's pseudorange ρ^b and GPS's pseudorange ρ^g are as follows.

$$\rho_{it}^b = |r_t - r_{it}^b| + c\delta t_b + \varepsilon_{it} + v_{it}$$

$$= \sqrt{(X_t - X_{it}^b)^2 + (Y_t - Y_{it}^b)^2 + (Z_t - Z_{it}^b)^2} + c\delta t_b + \varepsilon_{it} + v_{it}$$

$$\rho_{jt}^g = |r_t - r_{jt}^g| + c\delta t_g + \varepsilon_{jt} + v_{jt}$$

$$= \sqrt{(X_t - X_{jt}^g)^2 + (Y_t - Y_{jt}^g)^2 + (Z_t - Z_{jt}^g)^2} + c\delta t_g + \varepsilon_{jt} + v_{jt}$$

where, X_t, Y_t, Z_t are the receiver position coordinates, $X_{it}^b, Y_{it}^b, Z_{it}^b$ are the i th BDS satellite's coordinates, $X_{jt}^g, Y_{jt}^g, Z_{jt}^g$ are the j th GPS satellite's coordinates, ε_{it} is the non-white error in i th satellite channel, and v_{it} is the measurement noise of i th channel.

Doppler shifts give information related to the receiver velocity. Doppler is also used in our formulation, modeling it as:

$$D_{it} = \frac{(X_t - X_{it})(\dot{X}_t - \dot{X}_{it}) + (Y_t - Y_{it})(\dot{Y}_t - \dot{Y}_{it})}{\sqrt{(X_t - X_{it})^2 + (Y_t - Y_{it})^2 + (Z_t - Z_{it})^2}} + \frac{(Z_t - Z_{it})(\dot{Z}_t - \dot{Z}_{it})}{\sqrt{(X_t - X_{it})^2 + (Y_t - Y_{it})^2 + (Z_t - Z_{it})^2}} + c\dot{t} + \delta R_t$$

where $\dot{X}_t, \dot{Y}_t, \dot{Z}_t$ are velocity coordinate of receiver at time t ; $\dot{X}_{it}, \dot{Y}_{it}, \dot{Z}_{it}$ are velocity coordinate of i th satellite at time t .

So, the system measurement z_t for n satellites is given by:

$$z_t = [\rho_{1t}^b, \rho_{2t}^b, \dots, \rho_{n_1t}^b, \rho_{1t}^g, \rho_{2t}^g, \dots, \rho_{n_2t}^g, D_{1t}, D_{2t}, \dots, D_{nt}]^T$$

where $n = n_1 + n_2$. n_1 and n_2 are the number of measured BDS and GPS satellites.

VI. EXPERIMENT AND ANALYSIS

In the experiment, a set of BDS/GPS data collected by the NovAtel OEM-615 receiver is used. The position estimation is performed using the matlab in the PC environment. The raw data are processed using three algorithms: ILS, EKF and UKF.

The position estimation errors (x, y, z) are shown in Figures 1-3.

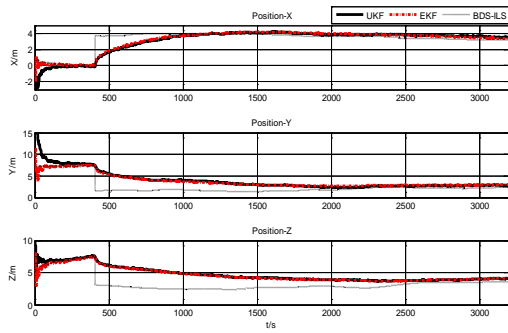


Figure 1 : Position Estimation Error using BDS's Data

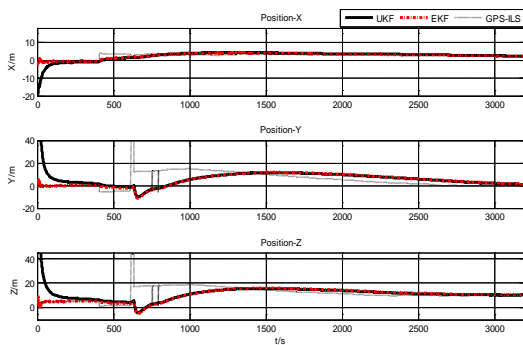


Figure 2 : Position Estimation Error using GPS's Data

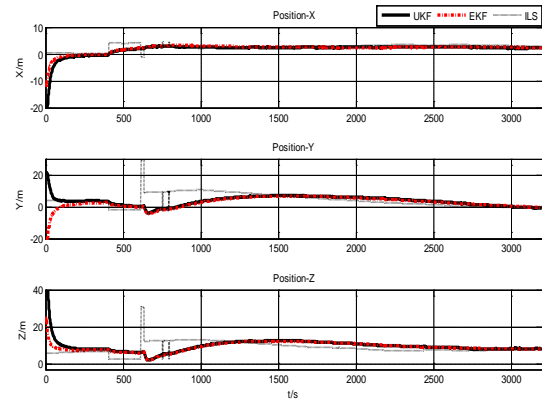


Figure 3 : Position Estimation Error using BDS/GPS's Data

The number of visible satellites during the experiment is shown in figure 4. Since the observation environment was good in the outdoor with a clear view of the sky, the number of BDS satellites was stable at 10, GPS satellite numbers changed between 6 and 7. The current BDS satellites are distributed in geostationary orbit (GEO) and inclined geosyn-chronous satellite orbit (IGSO) over China. That's why the BDS satellite number that is received is stable at present stage.

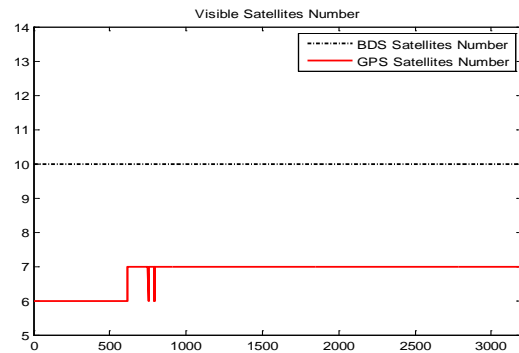


Figure 4 : The number of visible satellites

The correspondent root mean square errors (RMSE) are compared in table 1-3. It's not difficult to find whether BDS, GPS or BDS/GPS positioning, the result of the UKF has a higher accuracy than that of ILS and EKF.

Table 1 : Position Estimation Error using BDS's data

	RMSE/m			
	X	Y	Z	3D
ILS	3.429	4.487	4.879	7.463
EKF	3.437	4.065	4.770	7.148
UKF	3.438	3.136	3.655	5.917

Table 2 : Position Estimation Error using GPS's data

	RMSE/m			
	X	Y	Z	3D
ILS	3.464	9.086	12.948	16.193
EKF	3.013	8.396	12.743	15.555
UKF	3.031	7.055	11.330	13.687

Table 3 : Position Estimation Error using BDS/GPS's data

	RMSE/m			
	X	Y	Z	3D
ILS	2.979	6.077	10.437	12.439
EKF	2.880	4.681	9.521	10.994
UKF	2.573	4.345	9.308	10.589

When the number of the visible satellites is large, this method cannot fully represent its superiority. We have eliminated some of the original data so as to simulate the condition of less visible satellites, the case when the numbers of BDS and GPS were in the 2-3 range.

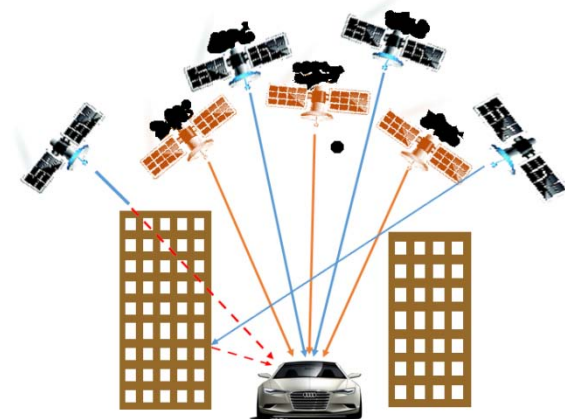


Figure 5 : Positioning with GPS and BDS under bad conditions

The positioning with BDS and GPS in bad environments is shown as figure 5.

In a single system, where there are less than four visible satellites, the positioning cannot be obtained by the conventional method, but a multi-system positioning model is a good way to deal with this situation. The number of visible satellites after part of them have been removed is shown in figure 6. BDS remained at three, but GPS changed in 2-3.

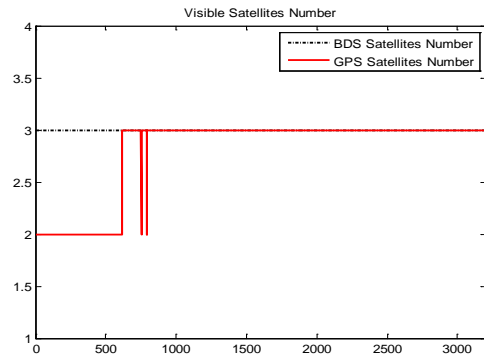


Figure 6 : The number of visible satellites after remove

When the number of satellites is less than four, the single system cannot be calculated; the advantage of multi-system positioning can now be represented. As long as the sum of BDS and GPS satellites is not less than five, the multi-system can be calculated effectively.

In figure 7, we can see that the number of satellites is going down, ILS algorithm's positioning precision is getting worse, and the rapid change in the number of satellites causes unsatisfactory results. Kalman filtering overcomes these difficulties well. Reduction in the number of satellites does not have a significant impact on the positioning result.

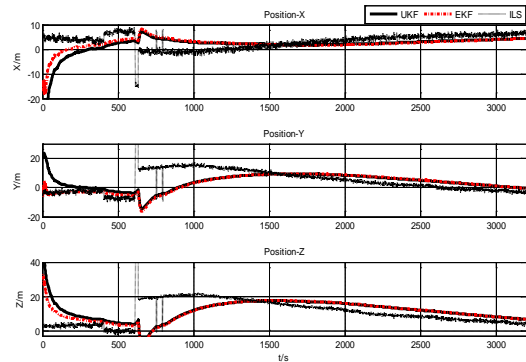


Figure 7 : Estimation Error using BDS/GPS's Data after removal

Table 4 : Position Estimation Error using BDS/GPS's data after removal

	RMSE/m			
	X	Y	Z	3D
ILS	4.491	8.981	13.240	16.488
EKF	4.425	6.456	13.078	15.241
UKF	3.492	6.371	12.519	14.475

The correspondent root mean square errors of the various methods are compared in table 4. It is not difficult to find that the result of the modified UKF has the highest accuracy. When the number of BDS or GPS satellites is too few to calculate in each single



positioning system, we can adopt the multi-system positioning method. We can get the results by using the ILS algorithm, but the error is too large and it does not meet the requirements of practical application. The Kalman filtering algorithm of the multi-system can still maintain high precision, and it has a huge advantage.

VII. CONCLUSION

In this paper, the multi-system position estimation algorithm which uses the UKF algorithm was proposed, which was verified by the real BDS/GPS data. We improved new nonlinear positioning models for the two navigation systems. After analysing the characteristics of BDS and GPS, the unity of time and space of the two systems was considered. We selected the BDT as the time standard, and the CGCS2000 as the coordinate standard. The proposed models can well address the frequent change of the GNSS satellites. The experimental result shows that the performance of the algorithm is better than ILS and EKF algorithms. On the other hand, UKF and EKF algorithms reach higher stability than ILS algorithm. Thus the proposed method also can be used in multi-system position estimation under the bad positioning conditions. In a single system when there are less than four visible satellites, the positioning cannot be obtained by the conventional method. However, using the proposed nonlinear positioning models, the high precision positioning can be solved as long as the sum of the satellites is no less than five in the dual system. In addition, the positioning accuracy is much higher than the result obtained by the iterative least square algorithm. Future work will include the implement of the other nonlinear filters with the proposed GNSS positioning models.

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Time Stretching using Phase Vocoder

By Vignesh Ganesan

Introduction- Time Scale Modification (TSM) is a principle that is used to modify the time axis or time resolution. This concept can be used in Audio processing as well as Image processing. In this research work, TSM concept is used to perform Time Stretching of an audio signal. In this concept, the speed of the audio playback is changed without affecting audio signal's pitch. The time stretching concept has been used extensively in different application, such as in post production for effects, during music mixing. This is also used in the application to capture or play back a slow motion video. If we look at the current scenario, Time Stretching is extensively used in the field of entertainment, and creative arts.

My paper talks about using this Time Stretching in the Automobile Industry. Now a days we have different types of FM stations (Digital and Analog). There is one particular scenario which I have considered as the Problem statement.

GJCST-G Classification : I.4.1, I.4.0



Strictly as per the compliance and regulations of:



Time Stretching using Phase Vocoder

Vignesh Ganesan

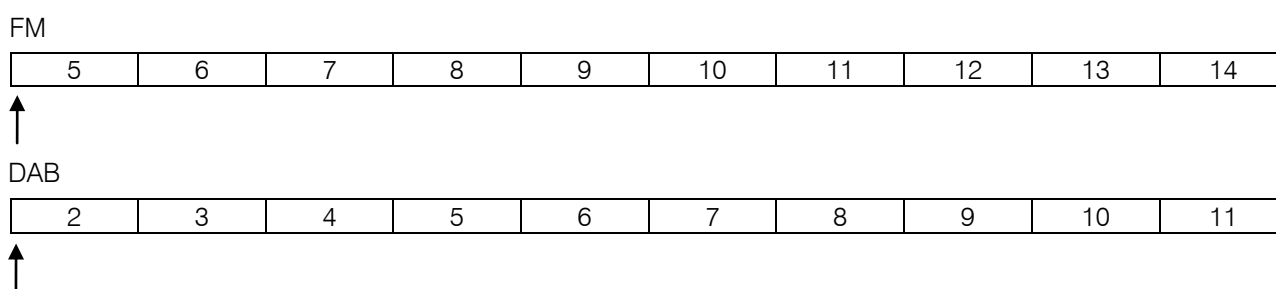
I. INTRODUCTION

Time Scale Modification (TSM) is a principle that is used to modify the time axis or time resolution. This concept can be used in Audio processing as well as Image processing. In this research work, TSM concept is used to perform Time Stretching of an audio signal. In this concept, the speed of the audio playback is changed without affecting audio signal's pitch. The time stretching concept has been used extensively in different application, such as in post production for effects, during music mixing. This is also used in the application to capture or play back a slow motion video. If we look at the current scenario, Time Stretching is extensively used in the field of entertainment, and creative arts.

My paper talks about using this Time Stretching in the Automobile Industry. Now a days we have different types of FM stations (Digital and Analog). There is one particular scenario which I have considered as the Problem statement.

II. USE CASE SCENARIO : FM-DAB LINKING

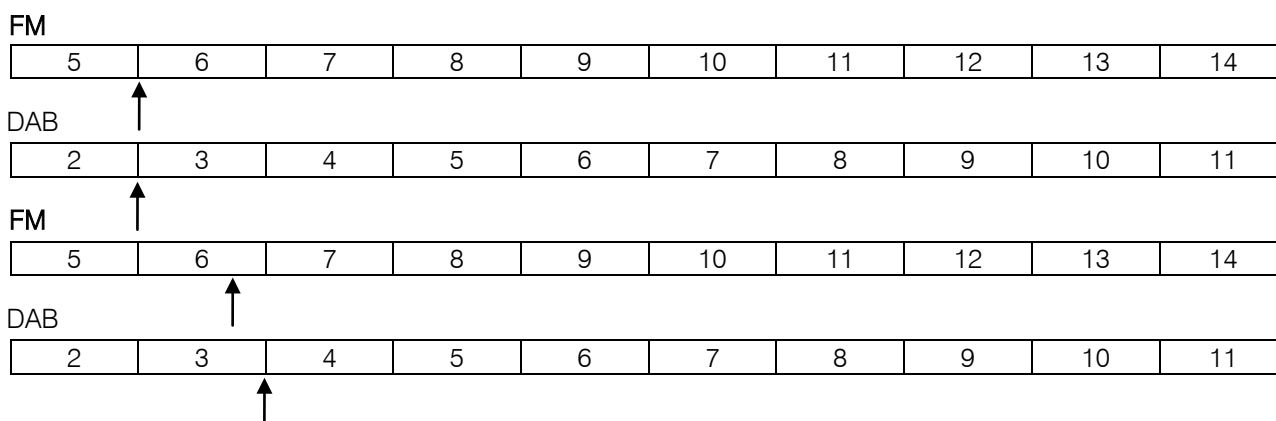
In the concept of Seamless Linking, the FM (Frequency Modulation) would be playing ahead of DAB (Digital Audio Broadcasting). In this case, when switching is necessary from FM to DAB, we would need to wait for an amount 3 seconds (assuming that the delay between FM and DAB is 3 seconds).



Assuming a delay of 3 seconds, In the above example, FM is playing the 5th second of an audio, at the same instant DAB would be playing the 2nd second of the same audio. Now at this point if we need to switch from FM to DAB, we would again hear, 2,3 and 4th second audio before hearing the 5th second audio, So 3 seconds of audio will repeat. In alternate case, if we do not want to hear the same audio again, there would be 3 seconds of audio mute and playback would resume from 5th second in DAB.

In seamless linking this is avoided and a concept called Time Stretching is introduced. In the same example, without switching it immediately, the FM signal from 6th second till 11th second (total duration 6seconds) is stretched to 9 seconds.

The following buffer diagram depicts different stages of stretching and its corresponding pointer location of the DAB signal.



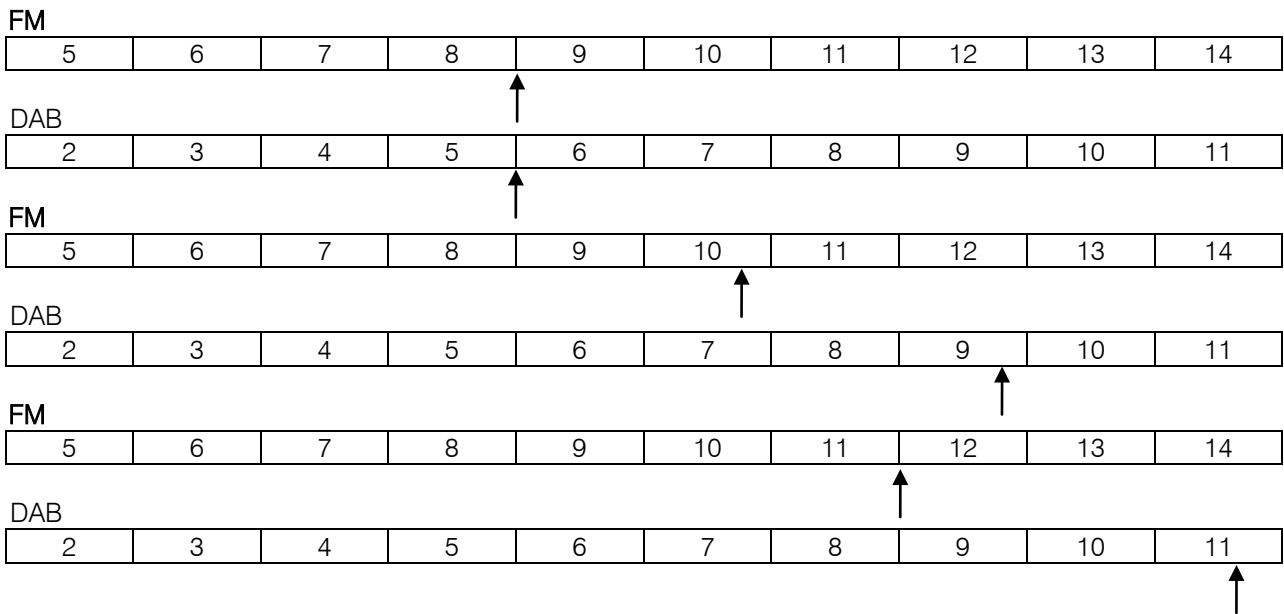


Figure 1 : Use Case

CASE

At the end of time stretching (last diagram) we can see that the pointer of FM and DAB are pointing to

the same time slot. Now if we switch from FM to DAB, there would not be any difference in the content being played.

III. ALGORITHM OVERVIEW

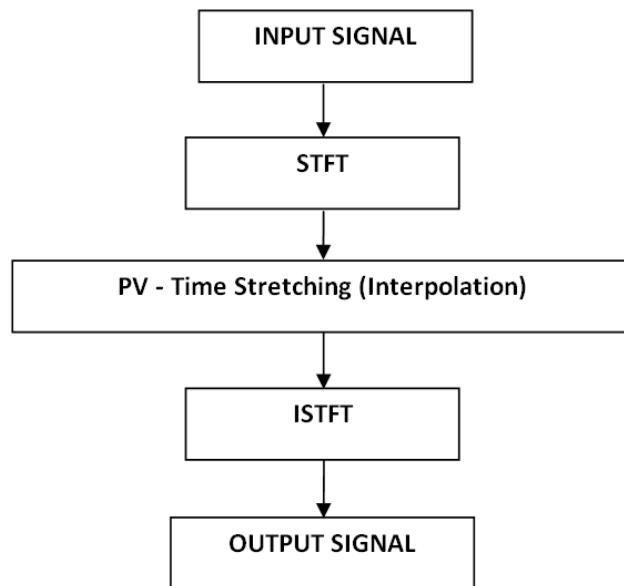


Figure 2 : Software Architecture

IV. ARCHITECTURE DIAGRAM

The Fig 2 represents the overall block diagram of the entire time stretching process. The algorithm is developed in such a way that the quality of the output audio is good and at the same time the computational complexity is minimum, considering the fact that this algorithm needs to be used in a real time embedded system for an automobile.

V. ALGORITHM IMPLEMENTATION

Phase Vocoder is the basic principle behind Time Stretching. This concept involves conversion of time domain into frequency domain. The implementation involves totally 3 stages.

Stage 1: STFT

Input to this stage is a pure Time Domain signal, it can be any format, mono, stereo or surround

channel etc. The algorithm has been designed in such a way to accommodate different number of channel. For every channel the same process would be applied. Being the 1st stage, it is responsible for converting the time domain signal to a frequency domain signal. The concept that has been applied here is Short Time Fourier Transform. In general cases a Fourier Transform would be sufficient to convert the time domain signal to a frequency domain signal. This would only result in a single conversion and we would not have much details about what frequency is present at what instant of time. To get more precise details about which frequency is present at which time slot STFT is carried out. This is done taking FFT to the signal at different time slots. The output of this stage would be a Multi Dimensional array with each column representing frequency component at a particular time slot.

Stage 2: Phase Vocoder

The output of the STFT stage will act as the input to this stage. This module performs the core of time stretching. Phase Vocoder stretches time in frequency domain. The input data to this stage is in complex form and is in frequency domain. Interpolation is the backbone concept of this Phase Vocoder. The

algorithm estimates a phasor, which is used to modify the existing sample at a different time position. In this algorithm, I have used interpolation using two columns. The output of this stage will be in frequency domain, it would be a multi dimensional array (2D Matrix) having same number of rows as the input but number of columns would vary according to the stretching desired.

Stage 3: ISTFT

This stage performs Inverse STFT. Input to this module is the output of the Phase Vocoder. Here IFFT has to be performed several times to get back the stretched time domain signal. The only major difference in applying the IFFT is that the output of every IFFT has to follow overlap addition process. This overlap method will avoid the phase discontinuity and amplitude reduction at the frame border.

VI. SIMULATION RESULTS

Implementation of this algorithm has been successfully evaluated in MATLAB Platform. Both graphical evaluation and psychoacoustic listening tests were also conducted. Some of the simulation results are described below.

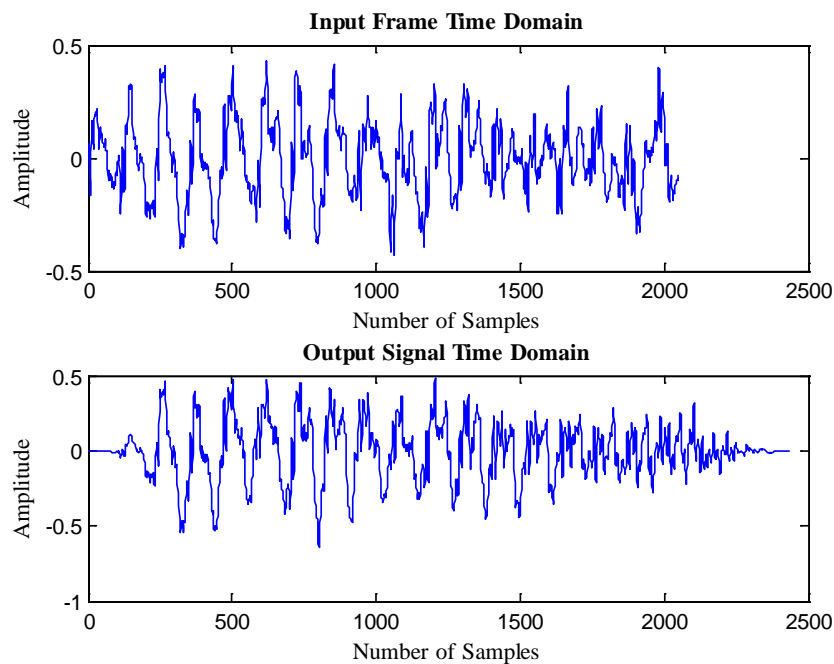


Figure 3 : Audio Time Stretching (Frame by Frame): Input Frame vs Stretched Output Frame

Fig.3. represents the analysis of just one frame iteration. According to the above iteration, the input is of 2048 samples and from the output graph it is evident that it has been stretched close to 2450 samples. This output will not be the final data written to the file. There will be overlap addition taking place, so that the end segment will be compensated and there would be no data loss.

This graphical representation is just for a basic understanding of how this algorithm works frame by frame. The next representation would show the overall input vs output audio signal with respect to the entire song duration of 6 seconds.

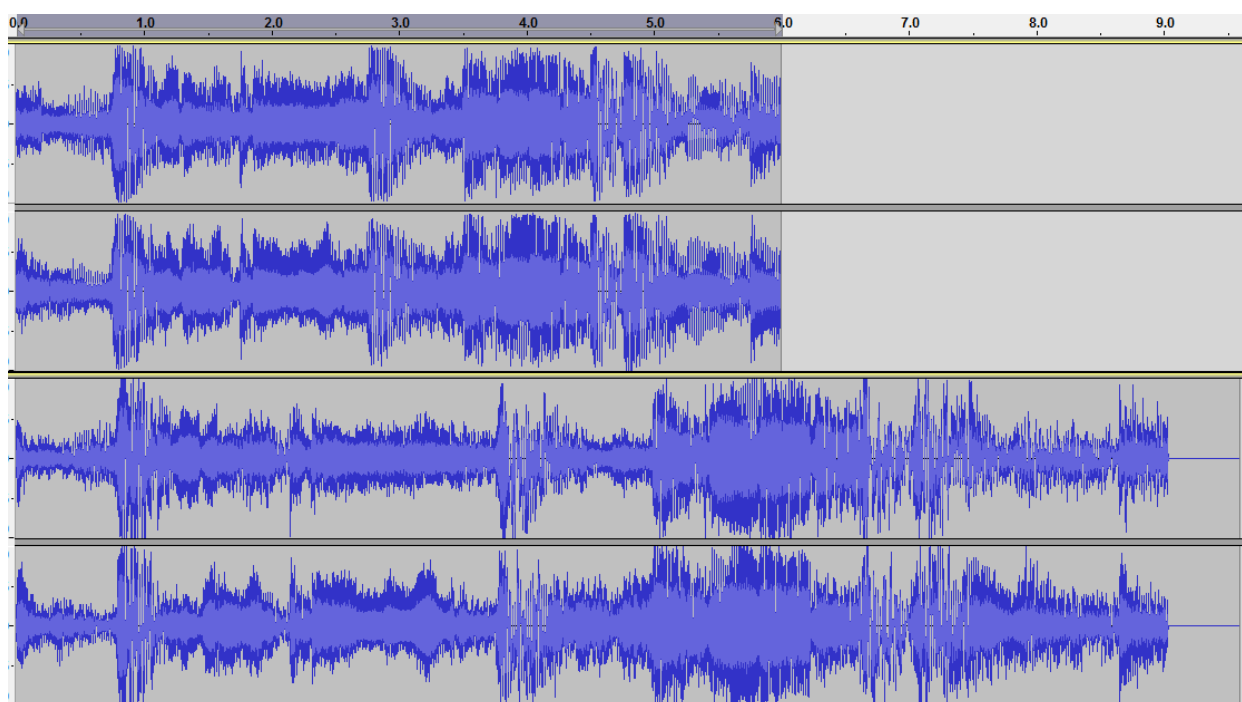


Figure 4 : Audio Time Stretching: Original Input (Top) vs Stretched Output (Bottom)

From Fig.4. one can observe that the audio has been stretched from 6 seconds to 9 seconds. The top audio graph is that of the original input and the below one represents the stretched output. Both the audio signals are in time domain. Almost 10 different types of audio was tested and the quality was verified.

VII. CONCLUSION AND FUTURE SCOPE

Though this algorithm was mainly created and developed to work for real time scenario, at present this algorithm has been successfully tested and verified under MATLAB platform. Once this algorithm is converted to Embedded C domain, then it would work in real time scenario. This algorithm needs to be linked to a seamless linking algorithm for maximum efficiency. To achieve that just certain parameters needs to be tweaked and nothing major needs to be done at the root level of the algorithm.

In general cases of Time Stretching, the audio is processed for the entire selection or a file, but in this concept it works on a frame by frame basis which is what makes it unique to work in a real time scenario such as an Automobile.

The phase discontinuity is suppressed almost to an unnoticeable change, and the phasiness effect has also been reduced. This algorithm has been designed for an optimal solution which is a good enough quality (the effect of time stretching is not too disturbing for the human ear), and a medium sized computational complexity.



The Generalized Estimating Equations for the Unknown Correlation Structure of the Data

By Md. Soyebur Rahman, Shayla Naznin & Gowranga Kumar Paul

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In the study the data are taken from the Dhaka stock exchange (DSE) this data are highly correlated. At first we apply different methods of estimating parameter the we apply GEE for estimating the parameters. Finally we get the GEE gives better estimate than any other method.

Keywords: *generalized estimating equation, GEE, OLS, GLM.*

GJCST-G Classification : *G.1.5, G.1.6*



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The Generalized Estimating Equations for the Unknown Correlation Structure of the Data

Md. Soyebur Rahman ^α, Shayla Naznin ^σ & Gowranga Kumar Paul ^ρ

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I. INTRODUCTION

The term Generalized Estimating Equations indicates that an estimating equation is not the result of a likelihood-based derivation, but that it is obtained by generalizing other estimating equation. Liang and Zeger (1986), Zeger and Liang (1986) and prentice (1988) developed a most recent method of estimating the parameters of the marginal model. They present a class of estimating equations that take the correlation into account to increase the efficiency. This class of estimating equations is called Generalized Estimating Equations (GEE) and the correlation matrix is called working correlation matrix. The name working is used in the sense that it is an approximate correlation matrix of Y_i 's (the response variable). The estimates of β obtained by GEE are consistent and in addition

consistent variance estimates can be obtained under the weak assumption the weighted average of the estimated correlation matrices converge to a fixed matrix.

II. DATA ANALYSIS

The stock exchange data are highly correlated from one company to other company.

In our study, we have used stock exchange data because, we want to compare the different method of estimation. We have taken six company and their closing price and the general index in 2009 of DSE. In our calculation we have taken general index as an explanatory variable and the different company closing price as a independent variable.

We want to estimate the following model

$$y = \beta_0 + \beta_1 X_1 + \beta_3 X_3 + \dots + \beta_6 X_6 \quad (1)$$

where,

y = DSE general index 2009

X_1 = Aims first guaranteed mutual fund

X_2 =ACI pharmaceuticals Limited

X_3 =Glasco Smith-kline Bangladesh Limited

X_4 =Beximco Pharmaceuticals Limited

X_5 =Al-Arafah Islami Bank Limited

X_6 =Bata Shoe Company (Bangladesh) Limited.

Calculation of the model (1) in the different methods as follows:

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-101.01708	244.3919221	-0.413341	0.679737	-582.5174	380.48328
X Variable 1	-27.610049	7.774982161	-3.55114	0.000464	-42.9283	-12.291798
X Variable 2	-7.917902	1.068852888	-7.40785	2.34E-12	-10.02375	-5.8120506
X Variable 3	2.2945252	0.397909548	5.766449	2.56E-08	1.510565	3.0784856
X Variable 4	13.603066	1.598677955	8.508947	2.16E-15	10.45336	16.752778
X Variable 5	3.2163438	0.279808985	11.49478	1.61E-24	2.665065	3.7676227
X Variable 6	1.6285946	0.833022998	1.955042	0.051774	-0.012625	3.2698144

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Using the GLM procedure
 The GLM Procedure
 Standard

Parameter	Estimate	Error	t Value	Pr > t
Intercept	-97.97753227	244.4865048	-0.40	0.6890
x1	-27.79733308	7.7704859	-3.58	0.0004
X2	-7.88169809	1.0654488	-7.40	<.0001
X3	2.29819026	0.3979271	5.78	<.0001
X4	13.56079439	1.5965023	8.49	<.0001
X5	3.20755189	0.2794746	11.48	<.0001
X6	1.63484104	0.8332389	1.96	0.0509

Using GEE procedure
 The GENMOD Procedure

Analysis of Initial Parameter Estimates

Parameter	DF	Estimate	Error	Standard Wald 95% Confidence Chi-		
				Limits	Square	Pr > ChiSq
Intercept	1	-97.9775	240.8947	-570.122	374.1674	0.17 0.6842
x1	1	-27.7973	7.6563	-42.8035	-12.7912	13.18 0.0003
X2	1	-7.8817	1.0498	-9.9393	-5.8241	56.37 <.0001
X3	1	2.2982	0.3921	1.5297	3.0667	34.36 <.0001
X4	1	13.5608	1.5730	10.4777	16.6439	74.32 <.0001
X5	1	3.2076	0.2754	2.6678	3.7473	135.68 <.0001
X6	1	1.6348	0.8210	0.0257	3.2440	3.97 0.0464
Scale	1	162.6532	7.4241	148.7342	177.8748	

III. SUMMARY AND CONCLUSION

Selection of correlation structure is an important issue in Generalized Estimating Equation (GEE). We have earlier stated that there are four correlation structure namely, independent, exchangeable, autoregressive and pair wise. One needs to select under which correlation structure is unknown GEE works well or provides efficient estimate in several situation.

We have concentrated on standard error as a measure of accuracy for an estimator of the parameter. So in this case, we look only on the standard error under different correlation structure of different methods of estimation procedure.

In this study we consider stock exchange data, this data are highly correlated.

In the previous situation, we see that the standard error of the parameters of the GEE method is lowest than any other method. From this study we may conclude that from different method of estimation the GEE parameters are gives the efficient estimate and best approach.

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An Intelligent Framework for Natural Language Stems Processing

By Abid Thyab Al Ajeeli

Abstract- This work describes an intelligent framework that enables the derivation of stems from inflected words. Word stemming is one of the most important factors affecting the performance of many language applications including parsing, syntactic analysis, speech recognition, retrieval systems, medical systems, tutoring systems, biological systems,..., and translation systems. Computational stemming is essential for dealing with some natural language processing such as Arabic Language, since Arabic is a highly inflected language. Computational stemming is an urgent necessity for dealing with Arabic natural language processing. The framework is based on logic programming that creates a program to enabling the computer to reason logically.

This framework provides information on semantics of words and resolves ambiguity. It determines the position of each addition or bound morpheme and identifies whether the inflected word is a subject, object, or something else. Position identification (expression) is vital for enhancing understandability mechanisms. The proposed framework adapts bi-directional approaches. It can deduce morphemes from inflected words or it can build inflected words from stems. The proposed framework handles multi-word expressions and identification of names.

Keywords: natural language, knowledge base, morphological analysis, inflected words, logic-based, definite-clause, context-free grammar.

GJCST-G Classification : D.3.3, H.2.3



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This framework is based on using predicates in first-order logic with object-oriented programming convention which can address problems of complexity. This complexity of natural language processing comes from the huge amount of storage required. This storage reduces the efficiency of the software system. In order to deal with this complexity, the research uses Prolog as it is based on efficient and simple proof routines. It has dynamic memory allocation of automatic garbage collection. This facility, in addition to relieve the programmers from the notions of memory usage, makes it possible for class hierarchies, inheritance, and message passing to be generated automatically at run time. That means the logic programming language has capabilities for developing oriented mechanisms that can be taught about classes or new relationships between existing classes.

Keywords: *natural language, knowledge base, morphological analysis, inflected words, logic-based, definite-clause, context-free grammar.*

1. INTRODUCTION

Word stemming is one of the most important factors affecting the performance of many natural language processing applications such information retrieving systems, machine pattern

recognition, machine translation, speech tagging, and many other systems. The study of natural language processing using computers is as old as the introduction of computer software. Advances in this area lead to the improvement of man-machine communications. In particular, interfaces to databases and intelligent systems can handle interaction in restricted subsets of natural languages.

Natural language processing is a computer activity in which computers are entailed to analyze, understand, alter, or generate natural language objects. This includes the automation of any or all linguistic forms, activities, or methods of communication, such as conversation, correspondence, reading, dictation, publishing, translation, lip reading, ..., and written composition. Natural language processing is also the name of the branch of computer science, artificial intelligence, and linguistics concerned with enabling computers to engage in communication using natural language(s) in all forms, including but not limited to speech, print, writing, and signing (Foss 2004).

The Arabic language is one of the major natural languages that place a great deal of emphasis on morphology and syntax. More than 250 million people speak it. Arabic is a synthetic or in other words, highly inflected language. This means that the syntactic relationship between nouns are indicated by case ending and that verbs are inflected by means of prefixes, infixes, and suffixes to indicate the various persons, numbers, genders, derived forms, moods, and tenses. Traditional Arabic morphology is described in terms of roots and patterns. Roots are not words but sequences of three or more consonants.

In addition, Arabic language has a number of implications for the design of computer systems in general. It has also quite distinguishable characteristics that will add new aspects to natural language processing. The technique used in this work is based on two-level descriptions of Arabic morphology. This approach will make affixes (prefixes, infixes, and suffixes) more easily understood and handled. The two-level descriptions will be based on finite-automata and regular expressions. But, first, a review of the basic concepts of finite automata and the basic text processing machines will be introduced and adapted to capture Arabic structure concepts (Kelley, 1995; Hopcroft & Ullman 1979).

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Formally, a finite automaton is defined by a 5-tuple $(Q, \Sigma, \delta, q_0, F)$ where:

- Q is a finite set of states q_0, q_1, \dots, q_n ,
- Σ is a finite input alphabet (a set of symbols),
- $q_0 \in Q$ is the initial state,
- $F \subseteq Q$ is the set of final states, and
- δ is the partial transition function mapping $Q \times (\Sigma + \{\epsilon\})$ to zero or more elements of Q .

For example, $\delta(q, \hat{a})$ describes the next states, for each state q and input symbol \hat{a} or it is undefined. The notion of using finite automata is to model lexical analyzer, syntactic analyzer, and even to associate semantics with morphemes.

In this paper, we describe a software system that has the capability of embodying some parts of expert's facilities. The grammar rules of Arabic language are transformed into first-order predicate logic, using the programming language Prolog. The rules are developed to analyze and to extract semantic information from Arabic texts. The first-order predicate logic provides three levels of analysis:

1. *Syntax*: Which deals with grammatical structure of the underlying natural language. In addition to, the opportunity of encoding meaning.
2. *Semantics*: Deals with the literal meaning with the opportunity of including rules for wider meaning contexts, and
3. *Pragmatics*: Deals with the real meaning of sentences.

Stemming is a heuristic process that chops off the ends of words to find the root word and often includes the removal of derived affixes. It is used to improve retrieval effectiveness and to reduce the size of indexing files. Stemming is a common method for morphological normalization of natural language texts. Modern information retrieval systems rely on such normalization techniques for automatic document processing tasks. High quality stemming is sometimes difficult in highly inflectional languages, for example, Arabic and Indic languages. Little research has been performed on designing algorithms for stemming of texts in those languages (Sahari N. et al., 2013).

Computational stemming is an urgent problem for Arabic Natural Language Processing, because Arabic is a highly inflected language. The existing stemmers have ignored the handling of multi-word expressions and identification of Arabic names (Alhanani & Abo Aziz 2011). For other inflected languages. Jain and Agrawa (2015) claimed that they manage to parse, for example, Hindi words to identify root words from inflected words using natural language processing (NLP) techniques.

In order to familiarize readers with the complexities involved in the analysis and construction of Arabic sentences, we illustrate briefly some of the funda-

mental features of Arabic (Ali 1988; Hamoody 1991; Al-Douri 1992; Al Daimi 1994).

- Arabic script is written from right to left.
- Arabic language is an inflectional language and the derivation in Arabic is based on morphological patterns and the verb plays a greater inflectional role. Furthermore, Arabic words are built up from roots representing lexical and semantic connecting elements. This is not the case, for example, with English, which employs the stem as a basis for word generation.
- Arabic offers the possibility of combining particles and affixed pronouns to words and it involves diacritization.
- Arabic is distinguished by its high syntactical flexibility. This flexibility includes: the omission of some prepositional phrases associated with verbs; the possibility of using several prepositions with the same verb while preserving the meaning; allowing more than one matching case between the verb and verbal subject and the adjective and its broken plural qualified and the sharpness of pronominalization phenomena where the pronouns usually indicate the original positions of the words before their extra-positioning, fronting and omission. In other words, Arabic allows a great deal of freedom in the ordering of words in a sentence. Thus, the syntax of the sentence can vary according to transformational mechanisms such as extra-position, fronting and omission, or according to syntactic replacement such as the use of an agent noun in place of a verb.
- Arabic language is distinguished by its high context sensitivity in several directions. On the writing level, the shape of a letter depends on the letter that precedes it and the one that follows it. On the syntactic level, the different synthetic coherence relations such as case ending, matching, connecting, associating and pro-nominalization represent various examples of syntactic context sensitivity. Furthermore, the context sensitivity feature extends to the lexicon where a lot of vocables are influenced by their associated words. The context sensitivity feature is not only limited to letters, words and sentences but also applied to the continuous context consisting of several sentences. Arabic sentences are embedded and normally connected by copulative, exceptive and adversative particles. For this reason it is more difficult to identify the end of an Arabic sentence than is the case with other languages.

There are a number of applications that directly borrow models and methods from both information retrieval (IR) and natural language processing (NLP). A short presentation of some of these applications is mentioned below (Indurkha et al., 2010):

1. Text categorization is a good example of an application where research has been conducted in the two communities, IR and NLP, in addition to, the Machine Learning and Data Mining ones. Text categorization aims at automatically assigning new documents to existing categories. Most approaches are currently based on machine learning, where classified documents are used to automatically learn a decision function. The way documents are represented directly derives from the vector-space model and the deferent weighting schemes (Can et al., 2008).
2. A second application where methods from both IR and NLP are used in document summarization, which aims at providing a summary, in a few sentences, of a document or a document collection. Current approaches focus on extracting key sentences or parts of sentences, from the document or document collection and displaying them in an appropriate way.
3. A third application is Biological NLP, which focuses on the processing of text documents in the biological domain. As for the medical domain, there exist several knowledge bases in the biological domain, which can be used to get a more accurate representation of documents. The kind of information searched for by biologists is complex, and one needs to deploy a whole range of technologies to be able to match the needs of biologists (Doms and Schroeder, 2005). For terms results in which a high proportion do not describe any relationship between the proteins. More precise queries, which include verbs describing interactions, such as 'interact' and 'regulate,' are of term used to significantly reduce the search space. Unfortunately the information loss is unknown and the retrieved abstracts still document other relationships, for example, a tight coupling between the indexing engine, the search engine, and the natural language processing engine is required. Interested readers are referred to (Chen and Sharp, 2004) for a detailed presentation of the models and methods deployed in this domain.
4. The fourth application is Question/Answering, which aims at providing precise answers, as opposed to whole documents or paragraphs as is traditionally the case in IR, to questions. Most Question/Answering systems rely on a tightly coupled combination of IR and NLP techniques, leading to systems that integrate many of the existing technologies of those two domains (Bouma et al., 2008; Chu-Carroll et al., 2002).

This paper is organized into a number of sections. The next section provides some background on related works. Section 3 provides a brief description of lexical analysis mechanisms. It points out the

relationship between lexical analysis processes and finite automata. Section 4 introduces the concepts of logic programming and how it can be applied to natural languages. Definite-clause grammar is explained in section 5. The proposed model is discussed in section 6. System implementation is discussed in section 7. Sections 8 and 9 draw a number of conclusions and suggest new future research directions

II. RELATED WORK

In linguistic morphology and information retrieval, stemming is the process of reducing inflected (or sometimes derived) words to their word stem, base or root form—generally a written word form. The stem need not be identical to the morphological root of the word; it is usually sufficient that related words map to the same stem, even if this stem is not in itself a valid root. Algorithms for stemming have been studied in computer science since the 1960s. Many search engines treat words with the same stem as synonyms as a kind of query expansion, a process called conflation. Stemming programs are commonly referred to as stemming algorithms or stemmers.

A stemmer for English, for example, should identify the string "cats" (and possibly "catlike", "catty" etc.) as based on the root "cat", and "stems", "stemmer", "stemming", "stemmed" as based on "stem". A stemming algorithm reduces the words "fishing", "fished", and "fisher" to the root word, "fish". On the other hand, "argue", "argued", "argues", "arguing", and "argus" reduce to the stem "argu" (illustrating the case where the stem is not itself a word or root) but "argument" and "arguments" reduce to the stem "argument"

Many areas of natural language syntax and semantics are a fruitful source of inspiration for computer languages and systems designers. The complexity of natural language and the high level of abstraction of most linguistic and semantic theories have motivated the emergence of highly abstract and transparent programming languages. One of the most striking examples is undoubtedly Prolog, initially designed for natural language parsing, via Metamorphosis Grammars (Colmerauer 1978).

For a few years, the Logic Programming paradigm has been augmented with a number of technical and formal devices designed to extend its expressive power. New logic programming languages have emerged, several of them motivated by natural language processing problems. Among them let us mention: CIL (Mukai 1985) designed to express in a direct way concepts of Situation Semantics, MOLOG (Farinas et al. 1985), an extension to Prolog designed to specify in a very simple and declarative way the semantics of modal operators and \sim , -Prolog (Nadathur and Miller 1988), designed to deal with X-expressions and X-reduction.

The Logic Programming paradigm has been augmented with the concept of constrained logic programming (CLP). The basic research done within this area amounts to specifying tools for a more refined control on the type of values or terms a variable in a program can stand for. Answers to goals can be intentional: they are sets of equations (constraints) rather than mere values. Furthermore, the idea at the operational level, incorrect assignments are filtered out as soon as they are encountered when building a proof, making thus proof procedures more efficient.

The first step of any language processing system is necessarily recognizing and identifying individual words in the text. The mechanism used to generate individual words must be based on word morphology. Morphology systems can be used to decompose words into word stems and word affixes. In addition, such systems can be used to specify mood, gender, number, and person.

Many systems have been designed to address this issue. For example, Hegazi, & El-Sharkawi (1986) developed a system that detects the roots of Arabic words. This system is used to detect and correct

mistakes in spelling and vowelization. Another example is a morphological analysis and generation system that is used to examine the input word for different word types and attempts to find all possible analyses (Saliba, & Al-Danan, 1989, Mayfield 2001).

Haddad (Haddad al et. 2005) claimed that research on computational Arabic is limited compared with English and European languages. For the last two decades, Arabic language received extensive focusing in the fields of morphological and syntactical with little attention on semantics and on deep analysis of its structures.

One of the major breakthroughs in the field of morphology was the two-level morphology. It is a general computational model for word-form recognition and generation (Koskeniemi, 1983). Lauri Karttunen and others produced a LISP implementation of the two-level morphology and named it KIMMO (Karttunen et al. 1992).

The KIMMO model consists of two components:

1. The rule component;
2. The lexical component (lexicon)

Figure 1 outlines the structure of the KIMMO model.

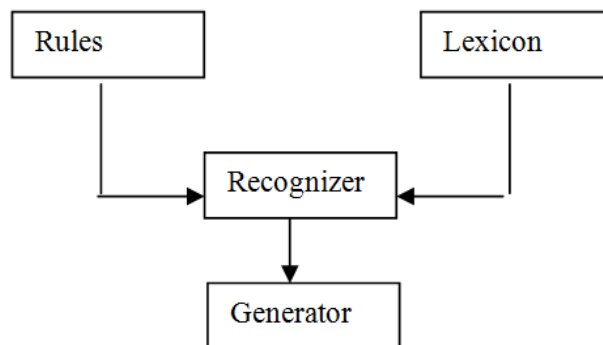


Figure 1 : The KIMMO model structure

In 1990, the Summer Institute of Linguistics produced PC-KIMMO version 1, an implementation of the two-level model written in C. This implementation was called PC-KIMMO (Antworth, 1990). This system had a serious deficiency: It could not determine the part of speech of a word or its inflectional categories (Antworth 1992; Xu 2002).

Al-Shalabi and Evens designed a computer system for Arabic morphology that employs a new and fast algorithm to find roots and patterns for verb forms and for nouns and adjectives derived from verbs (Al-Shalabi & Evens, 1998, Young-Suk 2003). For languages other than Arabic, a morphological syntax interface was proposed that separates syntactic function from morphological information in sequence projection architecture for the French language. This system was designed by Frank and Zaenen (2000). A number of morphological systems, based on finite-state analysis,

have also been developed by Beesley (1996, 1998a, 1998b).

III. LEXICAL ANALYSIS

Lexical analysis is the process of converting an input stream of characters into a set of words or tokens. Tokens are groups of characters with collective significance. Lexical analysis is the first stage of information gathering and natural language understanding.

The heart of a lexical analyzer generator is its algorithmic approach for producing a finite state machine. The algorithm presented in this paper is based on building finite automata with the minimum number of deterministic finite states using types of regular expressions adapted for lists of strings. During machine generation, the algorithm labels each state with the set of strings the machine would accept if that state were

the initial state. It is easy to examine these state labels to determine:

- The transition out of each state,
- The target state for each transition, and
- The states that are final.

To familiarize the reader with state labels, we provide examples that demonstrate the viability of the finite automaton mechanisms.

Case Study 1:

Suppose a state is labeled with the set of strings {a, an, any, and, in, into, to, too, many, more, most}. This state must have transitions on {a, i, t, and m}. The transition on a must go to states labeled with the set { n, nd, ε}, the transition on i goes to states labeled { n, nto } ,..., and the transition on t goes to states labeled {o,oo} as in Figure 2 (Frakes & Baeze-Yates 1992).

Figure 2 shows a typical finite state machine that can be used by a lexical analyzer algorithm where an initial states q_0 with an input {a, an, and, any} can produce a new state q_i , which could be a final state. In this case, the input left is $\in \{\epsilon, n, nd, ny\}$. Once the traversal reaches q_{11} then nothing of the specified input is left, i.e. $\{\epsilon\}$. The input is exhausted in a similar way if one travels along the edge $q_0 \rightarrow q_6 \rightarrow q_{10} \rightarrow q_{11}$

In other words, if we start reading the letter t at q_0 then control will be transferred to state q_6 with unexhausted input {o, oo}. If an o is read then this takes us to q_{10} which is an accepting state with input $\{\epsilon, o\}$. If no more input characters are read then input is terminated. If more input characters are available then we traverse the arc labeled {o} to state q_{11} , which is a final state, i.e., input is terminated.

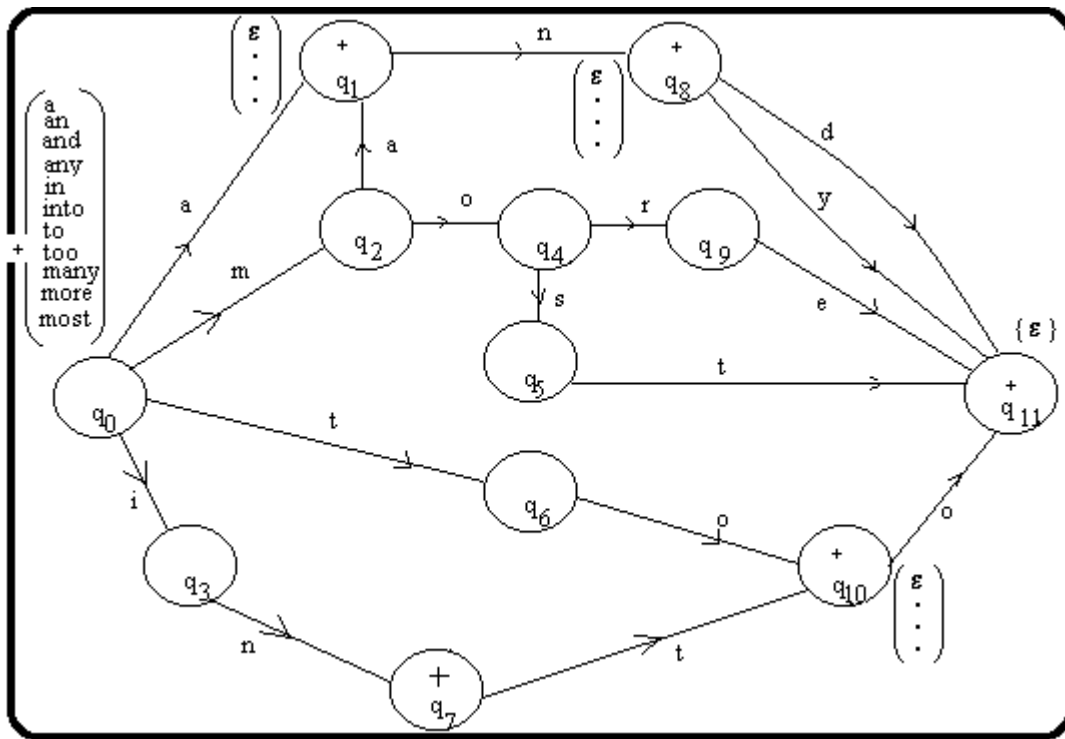


Figure 2 : Lexical analysis based on a finite automaton

Case Study 2:

This case study deals with strings from Arabic language. For the sake of readers unfamiliar with the Arabic Language words, we will first define the Arabic alphabet. The Arabic alphabet is an ordered set of 28 consonant letters:

{ ي، و، هـ، ن، م، ل، ك، ق، ف، غ، ع، ظ، ط، ض، ص، ش، س، ز، ر، ذ، ، د، خ، ح، ج، ث، ت، ب، أ }.

The initial state q_0 , of the finite machine, is labeled with the following set of strings

{.جامع، جامعة، يجمع، مجموع، مجموعة، جمع، جماعة}.

This set corresponds to {mosque, university, collect, total, sum, group of, summed up}. We want to

generate all words of the set from the morpheme "جمع". Figure 3 displays this example using a finite automaton representation.

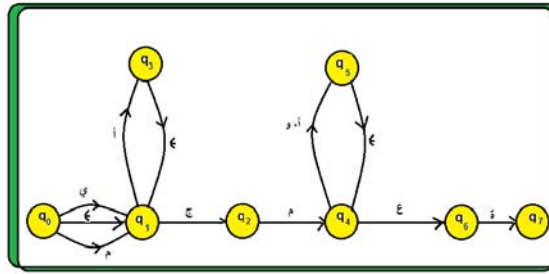


Figure 3 : Arabic Lexical Analyzer Based on Finite automaton

The morpheme " مجموع " , for example, can be constructed by the following arcs from $q_0 \rightarrow q_1 \rightarrow q_2 \rightarrow q_4 \rightarrow q_5 \rightarrow q_4 \rightarrow q_6$. This generation is applicable for the family of morphemes listed below:

جامع ، جامعة ، يجمع ، مجموع ، مجموعة ، جمع ، جماعة

If the building blocks of natural language texts are words, then words are important units of information, and language-based applications should include some mechanism for registering their structural properties. Finite state techniques have long been used to provide such a mechanism because of their computational

effectiveness, and because of their inevitability. They can both be used to generate morphologically complex forms from underlying representations, and parse morphologically complex forms into underlying representations (Indurkha & Damera 2010),

Case Study 3:

This case study demonstrates how a variety of strings can be generated using a simple finite automaton. For example, the string "قَمْنَا" in Figure 4, can be generated by the following arcs (reading from right to left) $0 \rightarrow 1 \rightarrow 5 \rightarrow 12 \rightarrow 16$.

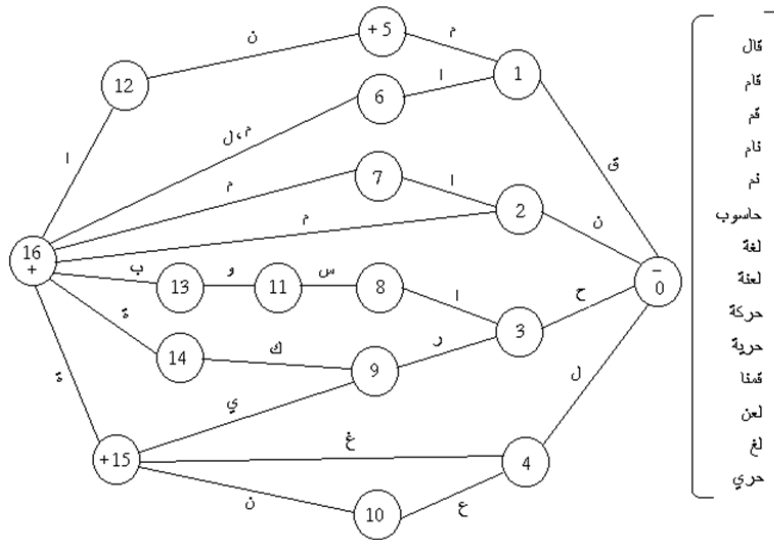


Figure 4 : Lexical Analyzer for Variety Sets of Strings

We believe that a lexical analyzer based on finite automata provides efficient mechanisms of converting strings of characters into useful tokens. It also provides efficient methods for developing Arabic spelling checkers.

IV. LOGIC PROGRAMMING AND NATURAL LANGUAGES

The rule-based approach has successfully been used in developing many natural language processing systems. Systems that use rule-based transformations are based on a core of solid linguistic knowledge. The linguistic knowledge acquired for one natural language

processing system may be reused to build knowledge required for a similar task in another system.

The motivations of the rule-based approach over the corpus-based approach a:

1. Less-resourced languages, for which large corpora, possibly parallel or bilingual, with representative structures and entities are neither available nor easily affordable, and
2. For morphologically rich languages, which even with the availability of corpora suffer from data sparseness.

These have motivated many researchers to fully or partially follow the rule based approach in developing

their Arabic natural processing tools and systems. In this paper we address our successful efforts that involved rule-based approach for different Arabic natural language processing tasks (Shaalan, K., 2010).

Natural language processing may require a huge amount of storage. This storage may reduce the efficiency of a software system. Using Prolog with object-oriented programming convention can address problems of complexity. Prolog is based on an efficient and simple proof routines (Warren, & Pereira, 1980). It has dynamic memory allocation of automatic garbage collection (Roth, 1992). This facility, in addition to relieve the programmers from the notions of memory usage, makes it possible for class hierarchies, inheritance, and message passing to be generated automatically at run time. That means, Prolog has capabilities for developing oriented programs that can be taught about classes or new relationships between existing classes.

The Prolog approach yields prototyping systems that can provide convenient methods for testing the viability of rules effectively. Although Prolog implementation may not produce fast enough systems for actual use, it provides developers with sufficient details and opportunities for efficiently designing, implementing, and testing systems (Veres and Molnar, 2010).

Using such an approach in developing software systems that analyzes natural languages can aid in producing software code in small sizes compared with conventional high-level languages. In addition, the software can be organized so that it can easily be developed, understood, and maintained. Prolog is suitable for designing definite-clause grammar by which the grammar rules of the language can be translated and then the underlying language becomes executable code in Prolog.

It is convenient to restrict attention to predicate logic programs written in clausal form. Such programs have an especially simple syntax that has the expressive power of the full predicate logic. A sentence is a finite set of clauses. A clause is a disjunction $L_1 \vee \dots \vee L_n$ of literals L_i which are atomic formulas $P(t_1, \dots, t_m)$ or the negations of atomic formulas $\neg P(t_1, \dots, t_m)$, where P is a predicate symbol and t_i are terms. Atomic formulas are positive literals. Negations of atomic formulas are negative literals. A term is either a variable or an expression $f(t_1, \dots, t_m)$ where f is a function symbol and t_i are terms. Constants are 0-ary function symbols. A set of clauses $\{C_1, \dots, C_n\}$ is interpreted as the conjunction, C_1 and \dots , and C_n . A clause C containing just the variables x_1, \dots, x_m is regarded as universally quantified for all x_1, \dots, x_m .

For every sentence S_1 predicate logic there exists a sentence S_2 in clausal form which is satisfiable if and only if S_1 is exist. For this reason, all questions concerning the validity or satisfiability of sentences in predicate logic can be addressed to sentences in

clausal form. Methods for transforming sentences into clausal form are described in (Nilsson, 1971). We have defined that part of the syntax of predicate logic which is concerned with the specification of well-formed formulas.

We know that we can often make "generate-and-test" more efficient by pushing the test closer to the generation. How can we do this in the current situation? We do this by letting predicates like noun perform both the recognition and the splitting. We do this by letting them accept the front of a list, and return the rest of the list (Kautz , 2004).

```
sentence(Tokens, Rest) :- nounphrase(Tokens, More),
                           verbphrase(More, Rest).
```

```
nounphrase(Tokens, Rest) :- det(Tokens, More),
                             noun(More, Rest).
```

```
verbphrase(Tokens, Rest) :- verb(Tokens, Rest).
```

```
verbphrase(Tokens, Rest) :- verb(Tokens, More),
                             nounphrase(More, Rest).
```

```
noun([man | Rest], Rest).
```

```
noun([apple | Rest], Rest).
```

```
verb([eats | Rest], Rest).
```

```
verb([sings | Rest], Rest).
```

```
det([the | Rest], Rest).
```

Queries can be issued as follows:

```
sentence([the, woman, eats, the, banana], Rest)
```

```
No.1 : Rest = [the, banana]
```

```
No.2 : Rest = [].
```

V. DEFINITE-CLAUSE GRAMMARS

The fundamental principle of normal language theory is that a language can be described in terms of how its sentences are constructed (Colmerauer, 1975). That is:

1. A sentence is a string (a sequence) of symbols defined by rules for strings
2. A language is a set of sentences defined by rules for sets.

According to the above definition, we can define a grammar as: a collection of rules for specifying what sequences of symbols are acceptable as sentences (statements) of that language.

Computer scientists have adapted the ideas of formal language theory to the study of natural languages, in the form of *context-free* grammars (CFGs). In CFGs the basic symbols or words of the language that they describe are identified by terminal and non-terminal symbols. The terminal symbols are basic constructs of the language. The non-terminal symbols can be factorized into terminal and/or non-terminal symbols. Colmerauer and Kowalski describe a

method to translate special purpose formalism CFGs into a general one in the form of *first-order* predicate logic (Colmerauer, 1975; Kowalski, 1974; Warren & Pereira, 1980). The method is known as a *Definite Clause Grammar* (DCG). According to DCGs, rules of a grammar describe which strings of symbols are valid statements of the language.

Parsing a rule of DCGs, using Prolog, is accomplished by transforming it into a theory and trying to prove its validity by applying logical reasoning. The proof either fails or succeeds. Pereira and Warren explain the efficiency of DCGs as follows:

"If a CFG is expressed in definite clauses according to the Colmerauer-Kowalski method, and executed as a Prolog program, the program behaves as a efficient top-down parser for the language that CFG describes. This fact becomes particularly significant when coupled with another discovery that the technique for translating CFGs into definite clauses has a simple generalization, resulting in a formalism far more powerful than CFGs, but equally amenable to execution by Prolog".

According to the Colmerauer-Kowalski claim, the definite-clause grammar mechanism is suitable for building a logic-based framework for computational linguistics.

VI. A LOGIC-BASED FRAMEWORK FOR INFLECTED LANGUAGE WORDS

There are several types of stemming algorithms with different performance and accuracy. The various algorithms are characterized by how certain stemming obstacles are overcome.

A simple stemmer algorithm looks up the inflected form in a lookup table. The advantages, of this algorithm, are simple, fast, and easily handle exceptions. The disadvantages are that all inflected forms must be explicitly listed in the table: new or unfamiliar words are not handled, even if they are perfectly regular (e.g. iPads ~ iPad), and the table may be large. For languages with simple morphology, like English, table sizes are modest, but highly inflected languages like Arabic may have hundreds of potential inflected forms for each root. A lookup approach may use preliminary part-of-speech tagging to avoid over stemming (Alhanini & Abo Aziz 2011).

The lookup table used by a stemmer is generally produced semi-automatically. For example, if the word is "run", then the inverted algorithm might automatically generate the forms "running", "runs", "runned", and "runly". The last two forms are valid constructions, but they are unlikely.

Suffix stripping algorithms do not rely on a lookup table that consists of inflected forms and root form relations. Instead, a typically smaller list of "rules" is stored which provides a path for the algorithm, given an

input word form, in order to find its root form. Some examples of the rules, from English texts for ease of readability only, include:

- If the word ends in 'ed', remove the 'ed',
- If the word ends in 'ing', remove the 'ing',
- If the word ends in 'ly', remove the 'ly'.

Suffix stripping algorithms enjoy the benefit of being much simpler to maintain than brute force algorithms, assuming the maintainer is sufficiently knowledgeable in the challenges of linguistics and morphology and be able to encoding suffix stripping rules. Suffix stripping algorithms are sometimes regarded as crude given the poor performance when dealing with exceptional relations (like 'ran' and 'run').

The solutions produced by suffix stripping algorithms are limited to those lexical categories which have well known suffixes with few exceptions. This, however, is a problem, as not all parts of speech have such a well formulated set of rules.

Suffix stripping algorithms may differ in results for a variety of reasons. One such reason is whether the algorithm constrains whether the output word must be a real word in the given language. Some approaches do not require the word to actually exist in the language lexicon (the set of all words in the language). Alternatively, some suffix stripping approaches maintain a database (a large list) of all known morphological word roots that exist as real words. These approaches check the list for the existence of the term prior to making a decision. Typically, if the term does not exist, alternate action is taken. This alternate action may involve several other criteria. The non-existence of an output term may serve to cause the algorithm to try alternate suffix stripping rules.

It can be the case that two or more suffix stripping rules apply to the same input term, which creates an ambiguity as to which rule to apply. The algorithm may assign (by human hand or stochastically) a priority to one rule or another. Or the algorithm may reject one rule application because it results in a non-existent term whereas the other overlapping rule does not. For example, given the English term *friendlies*, the algorithm may identify the *ies* suffix and apply the appropriate rule and achieve the result of *friendl*. *friendl* is likely not found in the lexicon, and therefore the rule is rejected (Dolamic, et al. 2007).

One improvement upon basic suffix stripping is the use of suffix substitution. Similar to a stripping rule, a substitution rule replaces a suffix with an alternate suffix. For example, there could exist a rule that replaces *ies* with *y*. How this affects the algorithm varies on the algorithm's design. To illustrate, the algorithm may identify that both the *ies* suffix stripping rule as well as the suffix substitution rule apply. Since the stripping rule results in a non-existent term in the lexicon, but the substitution rule does not, the substitution rule is applied

instead. In this example, Friendlies becomes friendly instead of friendl.

An intelligent framework based the above algorithms and on logic programming (logic-based) which enable deriving stems from inflected words (inflected words in Arabic language may form a complete meaningful sentence such as "انلزمكموها". The word "انلزمكموها" is a meaningful sentence which can be factorized into " أ + ن + لم + كم + و + هـ + ا " which can be written as: prefix* + stem + postfix* where prefix* and postfix* is a regular expression repeated zero or more times. The framework also provides semantics of

words and resolves ambiguity. It also determines the position for each addition (prefix, infix, or postfix) or bound morpheme and whether it is a subject, object or anything else. Position identification or position expression (الإعراب) is a vital necessity for enhancing understandability mechanisms. Our system is a bi-directional approach. It can deduce morphemes from inflected words or it can build inflected words from stems. The proposed software system is based on *Definite Clause Grammar* where rules are built according to patterns. Table 1 shows a sample of inflected morphemes.

Table 1 : Inflected Morphemes

Inflected morphemes	Postfix	Infix	Prefix	Stem
الدرس			الـ	درس
المغسلة	ة		الـ + م	غسل
أكبر			أ	كبر
أكل		و		أكل
علمهم	هم			علم
سهولة	ة	و		سهل
مساافر			م	سافر

In general, the inflected morphemes are modeled by definite-clause grammar rules as follows:

$$inflected-morphemes \rightarrow prefix + stem \mid prefix + stem + postfix \mid stem + infix \mid stem + infix + postfix \mid prefix + stem + infix + postfix$$

For example, the inflected morpheme سهولة can be identified as a pattern (templates) of the form "فعلولة" which has two additions: infix and postfix. The infix is " و " the postfix is " ة " and the stem is سهل according to a pattern of the form "فعل".

The finite automaton in figure 5 shows how rules can be used to derive morphemes when arcs are traversed in either direction.

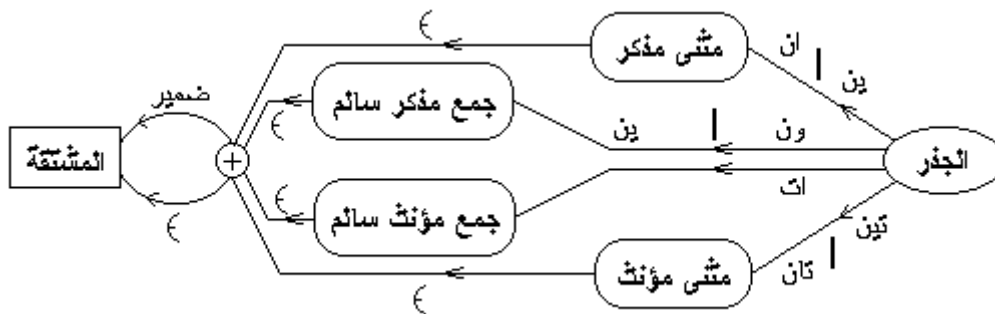


Figure 5 : Derivation Rules

Arabic language distinguishes between feminine and masculine morphemes. It also distinguishes between single, dual, feminine safe plural and/or masculine safe plural morphemes. Figure 5

shows how those can be generated. For example, dual masculine, dual feminine, masculine safe plural and feminine safe plural morphemes can respectively be modeled as follows:

- dual-masculine
- dual-masculine-derivation
- dual- feminine
- dual-masculine-derivation
- masculine-safe-plural
- masculine-safe-plural-derivation

- stem + " ين " | stem + " ان "
- dual-masculine + suffixes*
- stem + " تين " | stem + " تان "
- dual- feminine + suffixes*
- stem + " ون " | stem + " ين "
- masculine-safe-plural + suffixes*

feminine-safe-plural
 feminine-safe-plural-derivation

→ stem + " ات "
 → feminine-safe-plural + suffixes*

Where suffixes* is a regular expression that can be repeated zero or more times. It could be a pronoun and/or any other additives.

Previous researchers either store all inflected words in a lexicon, which is impractical and unrealistic, or store meaningful stems. The proposed approach is

based on special patterns (templates). It associates meaning with the basic roots in order to deduce morpheme meanings. As a result, when a text file is read, stems, bound morphemes, meaning, and positions are deduced. The architecture of the framework is outlined in figure (6).

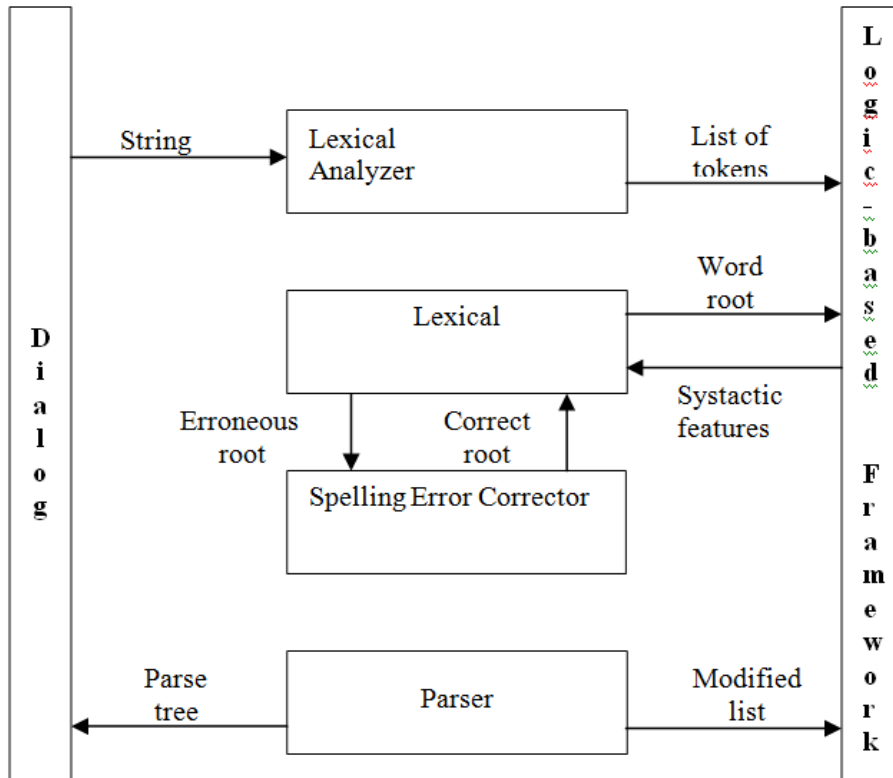


Figure (6) : Architecture of the Proposed Framework

The architecture of the framework is made up of a number of components. The dialog accepts a text and then passes it to the lexical analyzer in order to decompose the text into a list of tokens.

Morphological facts are usually represented as a set of features expressed as attribute value pairs, for example, number is equivalent to singular, tense is equivalent to past participle and so on. Association of morphological features has the notion of agreement, where the form of one word depends on the features of another, or elements of a certain constituent may share certain features.

This structure can be used either to generate the appropriate inflected forms from the base forms and

their feature specifications, or to give an analysis of the character strings in the reverse direction. Although our system deals only with the morphology for verbs and nouns derived from verbs or in other words verb sentences, it can easily be extended to incorporate other morphemes that are not derived from verbs, which we will address in our future work.

VII. SYSTEM IMPLEMENTATION

The system has been implemented using PDP Prolog running on an IBM-compatible machine. A number of experiments have been conducted and the average has been computed. Table 2 records some findings.

Table 2 : Performance Results

Experiment	Number of words analyzed (sentences)	Average percentage of successfully analyzed sentences
1	6554 words extracted from a book	93.25%
2	5466 words extracted from newspaper	93.21%
3	2269 words extracted from Quran	90.73%

The beauty of logic implementation is its ability to express output in a format readable by humans and by machines. It is possible to write rules that can be fired when outputs are required to be read automatically by computer programs.

The logic rules below provide bi-directional morphological analysis. Below is a small fragment of the Prolog program. For example, the first rule **run** is an abstracted predicate with two arguments. The first one is "list" which is an input argument. The second argument is "W_rest" which is an output argument returning a word or parts of a word that has not been recognized. List is then factorized into five positions; L1, أ, , L3, L4, and the rest is R. If an أ "الف" is found in the second place and, the word has more than four positions, then this predicate will be processed. Otherwise control will backtrack to the next predicate until a match has been found or failure has occurred. A sample of predicates in first-order logic that deals with inflected Arabic words is outlined below. There are several predicates, each deals with different alternative, as shown below.

```
run (List, W_rest):-
    List = [ L1, "", L3, L4 | R ],
    List1 = [ L1, "", L3, L4 ],
    collect(List1, W_rest),
    chk1( R, Type ),!,
    write( Type ).
```

```
run( List, W_rest):-
    List = [ L1, "", L3, L4 ],
    List1 = [ L1, "", L3, L4 ],
    collect(List1, W_rest).
```

```
run( List, W_rest):-
    List = [ L1, "ي", L3 ],
    List1 = [ L1, "", L3 ],
    collect(List1, W_rest).
```

```
run( List, W_rest):-
    List = [ L1, L2, "و" | R ],
    List1 = [ L1, L2, "ء" ],
    collect(List1, W_rest),
    chk1( R, Type ),!,
    write( Type ).
```

```
run(List, W_rest):-
    List = [ L1, "ي", "ن" | R ],
    List1 = [ L1, "", "ء" ],
    collect(List1, W_rest),
    chk1( R, Type ),!,
    write( Type ).
```

```
run(List, W_rest):-
    List = [ L1, "ي", L3 | R ],
    List1 = [L1, "", L3 ],
    collect(List1, W_rest),
    chk1(R, Type ),!,
    write(Type ).
```

```
run(List, W_rest):-
    collect(List, W_rest),
```

```
str_len(W_rest, 3),!,
write(W_rest),nl.
```

```
run(List, Verb):-
    List = [Ch1,Ch2,Ch3 | R],
    collect([Ch1, Ch2, Ch3], Verb ),
    chk1(R, Type),!,
    write(Type).
```

```
run(List, Verb):-
    List = [Ch1,Ch2,Ch3, Ch4 | R],
    Ch1 = "س", Ch2 <> "ل",
    collect(["", Ch1, Ch2, Ch3, Ch4], Verb ),
    chk1(R, Type),!,
    nl, write(Type).
```

```
run(List, Verb):-
    List = [Ch1,Ch2,Ch3, Ch4 | R],
    collect([Ch1, Ch2, Ch3, Ch4], Verb ),
    chk1(R, Type),!,
    nl, write(Type).
```

```
run(List, Verb):-
    List = [Ch1,Ch2,Ch3, Ch4, Ch5 | R],
    Ch1 = "س",
    collect(["", Ch1, Ch2, Ch3, Ch4, Ch5 ], Verb ),
    chk1(R, Type),!,
    nl, write(Type).
```

The sentences accepted by finite automata are regular sentences. In other words, there exists a finite automaton FA that accepts $S(r)$ for any regular expression r . The structure of the proposed framework accepts $S(r)$ in $O(|r|)$ time and space. Although minimization is not considered, an algorithm can be constructed to minimize a deterministic FA with n states in $O(|\Sigma|n \log n)$. A number of queries is listed in Appendix I.

VIII. FUTURE WORKS

The intelligent framework is expected to facilitate converting natural language chunks of text into more formal representations such as definite-clause grammar structures that are easier for computer programs to manipulate through the logic programming implementation. This facilitation will involve the identification of a specific semantic from multiple ones. These identifications can be derived from natural language expressions which take the form of organized notations of natural language concepts. The framework may be extended in future research so that be able to convert information from computer storage into readable human language form.

The future research should concentrate on devising methods for inducing transformation rules that map natural-language sentences into a formal query or command language. The approach assumes a formal grammar for the target representation language and learns transformation rules that exploit the non-terminal symbols in this grammar (Kate et al. 2005; Gildea et al.

2002). The learned transformation rules incrementally map a natural language sentence or its syntactic parse tree into a parse-tree for the target formal language.

The future work may include also an intelligent interface within the proposed framework to derive high quality items of information through the process of devising patterns and trends using statistical pattern learning.

IX. CONCLUSIONS

The logic programming approach has successfully been used in developing many natural language processing systems. Systems that use logic programming transformations are based on a core of solid linguistic knowledge. The linguistic knowledge acquired for one natural language processing system may be reused to build knowledge required for a similar task in another system. The advantage of the logic programming approach over the corpus-based approach is for less-resourced languages, for which large corpora, possibly parallel or bilingual, with representative structures and entities are neither available nor easily affordable, and for morphologically rich languages, which even with the availability of corpora suffer from data sparseness.

These have motivated many researchers to fully or partially follow the logic programming approach in developing their Arabic natural processing tools and systems. In this paper we address our successful efforts that involved rule-based approach for Arabic natural language processing tasks. The proposed system has been developed for deriving stems from inflected words using the logic programming language Prolog. The suggested design was based on:

- Knowledge-based mechanism embodying facts and rules,
- Inference mechanism uses the knowledge base, and a query mechanism initiated by users.

The intelligent framework is used to facilitate the analyses and understanding strings from natural language. The texts are first tokenized in order to identify patterns of characters in the stream and to produce a stream of words or tokens. The tokenized text is then parsed to recognize syntactic objects according to Arabic language grammar rules.

The proposed system is a step in the direction of analyzing and understanding natural language texts. It is also potentially useful for enhancing automatic translation (Domain Specific). We conclude that there is a good case to be made from the adaption of expert systems to be used for natural languages processing. This work opens the door for more multilingual stemming research that applies morphological rules of two or more languages simultaneously instead of rules for one single language when interpreting a search query.

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APPENDIX I

This appendix demonstrates the viability of the framework. Once the program has been executed a message is issued to users to enter a term (word) identity or a file name that the system will read from. When a word is entered, the framework will analyze words and break them down into their constituents.

Example 1: Enter a word? سنعلمونهم

When it is translated into English, it means, "we will let them to know". It is decomposed into:

- Future : س
- Indicates present verb : ي
- Subject : و
- One of the five known verbs : ن
- Object : هم
- Indicate plural objects : ا
- Stem** : علم

Example 2: Enter a word? سكتبانه

This word has been written incorrectly, the framework identifies it and issues a message to users to make sure that the word is a proper one.

Example 3: Enter a word? فسيعلمونهم

When it is translated into English, it means, "and we will let them to know ". It is decomposed into:

- Conjunction : ف
- Future : س
- Indicates present verb : ي
- Subject : و
- One of the five known verbs : ن
- Object : هم
- Indicates plural objects : ا
- Stem** : علم

Example 4: Enter a word? لتعلمونهم

When it is translated into English, it means, " So that you will know them ". It is decomposed into:

- Reasoning letter : ل
- Indicates present verb : ت
- Subject : و
- One of the five known verbs : ن
- Object : هن
- Stem** : علم

Example 5: Enter a word? قُمت

When it is translated into English, it means, "I stood ". It is decomposed into:

- Verb : قم
- Subject : ت
- Stem** : قام

Example 6: Enter a word? استرعى

When it is translated into English, it means, "To get attention ". It is decomposed into:

- Indicates present verb : ا



Continuous letters for request	: س، ت
Verb	: رعى
Stem	: رعى
<i>Example 7:</i> Enter a word? أنسانيه	
When it is translated into English, it means, "He makes me forget it ". It is decomposed into:	
Indicates present verb	: أ
Verb	: نسي
Letter N to indicate protection	: ن
First object	: ي
Second object	: ه
Stem	: نسي
<i>Example 8:</i> Enter a word? يجيئون	
When it is translated into English, it means, "They are coming ". It is decomposed into:	
Indicates present verb	: ي
Subject	: و
One of the 5 known verbs	: ن
Verb	: جاء
Stem	: جاء
<i>Example 9:</i> Enter a word? يتطهرن	
When it is translated into English, it means, "To get cleaned ". It is decomposed into:	
Indicates present verb	: ي
Letter T indicate Transitive verb	: ت
Verb	: طهر
Letter N indicate of the feminine	: ن
Stem	: طهر
<i>Example 10:</i> Enter a word? أسلم	
When it is translated into English, it means, "To get in Islam faith ". It is decomposed into:	
Indicates present verb	: أ
Verb	: سلم
Stem	: سلم
<i>Example 11:</i> Enter a word? لأموتن	
When it is translated into English, it means, "To die ". It is decomposed into:	
Reasoning letter	: ل
Indicates present verb	: أ
Verification letter	: ن
Verb	: مات
Stem	: مات
<i>Example 12:</i> Enter a word? قامت	
When it is translated into English, it means, "She stood ". It is decomposed into:	
Verb	: قام
Letter T indicates of the feminine	: ت
Stem	: قام
<i>Example 13:</i> Enter a word? ستواجه	
When it is translated into English, it means, "You will face ". It is decomposed into:	
Future	: س
Indicates present verb	: ت
Verb	: واجه

Stem

: واجه

Example 14: Enter a word? جاءهم

When it is translated into English, it means, "They are coming ". It is decomposed into:

Verb

: جاء

Object

: هم

Stem

: جاء

Example 15: Enter a word? أتاهم

When it is translated into English, it means, "He comes to them ". It is decomposed into:

Verb

: أتى

Object

: هم

Stem

: أتى





A New Bayesian Inference Methodology for Modeling Geochemical Elements in Soil with Covariates. Characterization of Lithium in South Iberian Range (Spain)

By Sergio Meseguer, Pablo Juan, Ana B. Vicente & Carlos Díaz-Avalos

University Jaume I of Castellón

Abstract- When the scientific need to model geochemical elements in soil, is using geostatistical methodologies, for instance krigings, but we can use a new possibility with Bayesian Inference. The models for the analysis were specified by the authors and estimated using Bayesian inference for Gaussian Markov Random Field (GMRF) through the Integrated Nested Laplace Approximation (INLA) algorithm. The results allow us to quantify and assess possible spatial relationships between the distribution of lithium and other possible explanatory elements. Are these other elements significant to the study? We believe the methods outlined here may help to find elements such as lithium, as well as contributing to the prediction and management of new extractions or prospection in a region in order to find each chemical element.

Keywords: *bayesian inference, iberian range, lithium, soil.*

GJCST-G Classification: C.2.1 C.2.2



Strictly as per the compliance and regulations of:



A New Bayesian Inference Methodology for Modeling Geochemical Elements in Soil with Covariates. Characterization of Lithium in South Iberian Range (Spain)

Sergio Meseguer ^α, Pablo Juan ^σ, Ana B. Vicente ^ρ & Carlos Díaz-Avalos ^ω

Abstract- When the scientific need to model geochemical elements in soil, is using geostatistical methodologies, for instance krigings, but we can use a new possibility with Bayesian Inference. The models for the analysis were specified by the authors and estimated using Bayesian inference for Gaussian Markov Random Field (GMRF) through the Integrated Nested Laplace Approximation (INLA) algorithm. The results allow us to quantify and assess possible spatial relationships between the distribution of lithium and other possible explanatory elements. Are these other elements significant to the study? We believe the methods outlined here may help to find elements such as lithium, as well as contributing to the prediction and management of new extractions or prospection in a region in order to find each chemical element. The application for the modeling is to study the spatial variation in the distribution of lithium and its relationship to other geochemical elements is analyzed in terms of the different possibilities offered by geographical and environmental factors. All in all, Lithium presents many important and meaningful uses and applications such as: ceramics and glass, electrical and electronics standing out lithium ion batteries, as well as a lubricator for greases, in metallurgy, pyrotechnics, air purification, optics, organic and polymer chemistry, and medicine. This study aims to examine the distribution of lithium in sediments from the area of Beceite, in the Iberian Range and the Catalan Coastal Range (Catalànids), within the geological context of the Iberian Plate. The Atlas Geoquímico de España (IGME, 2012) was used as the main geochemical data bank in order to carry out a statistical analysis study.

Keywords: bayesian inference, iberian range, lithium, soil.


1. INTRODUCTION

Lithium is a relatively rare element. Although lithium is found in many rocks and some brines, it is always present in very low concentrations. Lithium presents many important and meaningful uses and applications and the most important is electrical and electronics standing out lithium ion batteries, but not only this application, it is used as a lubricator for greases, in metallu

rgy, organic and polymer chemistry or medicine. The average amount in the earth's upper crust was estimated by Vine (1980) to be about 20 ppm, although others have reported values as low as 7 ppm (igneous rocks 6 ppm, sedimentary rocks 11.5 ppm) and as high as 60 ppm, this element ranking 27th on the list of abundance (Garrett et al., 2004).

Because of its small ionic radius, lithium (+1, 0.68 Å) tends to replace magnesium (+2, 0.66 Å) or iron (+2, 0.74 Å) in silicates rather than the much larger alkali ions, sodium (+1, 0.97 Å), potassium (+1, 1.33 Å), rubidium (+1, 1.47 Å) or caesium (+1, 1.67 Å), to which it is chemically more closely related (Ju-chin-Chen, 1998). Three main types of lithium ore can be differentiated: brines and related evaporites, pegmatites and sedimentary rocks. Brines containing lithium make up 66% of the world's lithium resources, pegmatites make up 26%, and sedimentary rocks account for the remaining 8% (Grubber et al., 2011). The deposits formed are related to lithium's greater capability for solubility than most other cations. Accordingly, it can sometimes be found concentrated in flowing and cooling magma and/or its associated aqueous solutions, besides also being present in evaporating brines. Lithium is associated with sedimentary rocks, including clay and lacustrine evaporites. In clay deposits, lithium is a constituent of clay minerals, such as smectite. A remarkable smectite in this environment would be Hectorite $[(Mg,Li)3Si_4O_{10}(OH)_2]$, which is rich in magnesium and lithium.

From the geochemical point of view, one of the main goals of this paper is to study the relationships of lithium with several other elements in an attempt to identify and establish trends in geochemical behaviour, within the geological context of a linking area under the influence of two tectonic domains, namely: the East Iberian range and the Catalan Coastal range. This area was remarkably tectonized by the Alpine orogeny in the Late Mesozoic and Cenozoic. Going a step further, another important aim is the study of the distribution of lithium, in relation with the potential atomic exchanges that occur in several crystalline structures – especially with the existence of Fe, Mg, K and Na. Furthermore,

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this study is a part of a more ambitious project that embraces a larger area.

In this paper is to present the prediction and the basic features of the Integrated Nested Laplace Approximation (INLA; Rue et al., 2009) approach as applied to geochemical spatial data. In previous studies of geochemical elements, it has been in Geostatistical Analysis context (Jordan et al., 2004; Juan et al., 2011), but now the INLA approach can be employed to improve the results. The INLA is designed for latent Gaussian models ranging from linear mixed to spatial and spatio-temporal models. For this reason, the INLA can be successfully used in a great variety of applications.

The paper is structured as follows. First, in Section 2 we review the main characteristics of the geochemical analysis of the data. In Section 3 the sampling data are presented, and this is followed by Section 4, where we detail the analysis of the data. We provide an overview of the theory underlying the INLA and we review the SPDE approach to dealing with spatial data in Section 5. The practical application to area-level data is presented in Section 6. After that, in Section 7, issues are discussed and some conclusions are set out.

II. GEOLOGICAL BACKGROUND

In order to understand better the geochemical content and its arrangement throughout the range is revised in a short way the geological context. In this way, the study area lies within the geological context of the Iberian Plate, close to the Iberian Range and the Catalan Coastal Range (Catalànids), and forms a single tectonic unit (Vera, 2004). The east-central margin of the Iberian Peninsula a relief which often exceeds 1000 m. in height as the result of two alpine structures that were partially destroyed there (Fig. 1).

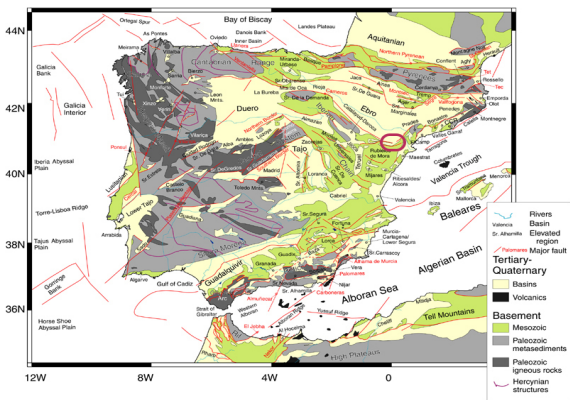


Figure 1: Geological map of the Iberian Peninsula and the western Mediterranean basins, major faults and regions (Andeweg, 2002).

The Iberian Range is over 400 km. long and extends from the Iberian Meseta to the Mediterranean Sea with a maximum width of 200 km. The Catalan Coastal Range constitutes a mountain barrier 200 km. in

length and 30-40 km. wide that runs parallel to the coast and separates the Ebro basin from the Mediterranean Sea.

Both structures, the Iberian Range and the Catalan Coastal Range, converge at their eastern and southern ends to form the Maestrat, where the area known in Spanish as “zona de enlace” is located (Fig. 2).

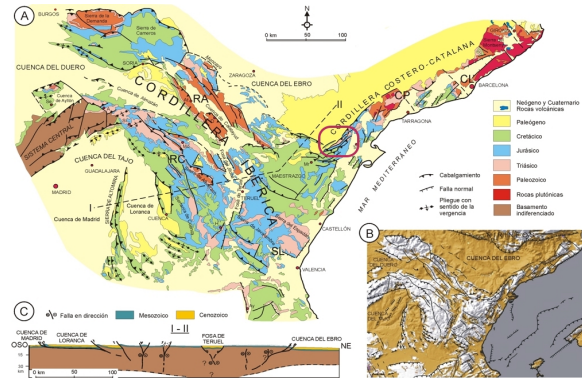


Figure 2: Geological map of the Iberian Range and Catalan Coastal Range (Vera, 2004).

It is made up of a fold-and-thrust belt running NW-SE (Iberian Range) and NE-SW (Catalànids) formed as a result of the Alpine reversion of the Mesozoic Iberian Basin. Its structure includes the fractured Hercynian basement, which has Alpine structures superimposed upon it that later underwent Neogene distension, especially in the south-east of the Iberian Range.

Most of the structural features of the Iberian Range are the result of the interaction of two factors: first, the reactivation of old compression fractures in the late Hercynian, NW-SE and NE-SW, and, secondly, the relationship between the cover and the underlying basement (Guimerà and Alvaro, 1990).

The tectonic style develops three structural levels characterized by the involvement of stratigraphic succession and deformation behaviours. The lower level consists of the Hercynian basement and overlying Permian and Triassic, while the upper level includes the Mesozoic (Jurassic and Cretaceous) and Cenozoic cover (bed) (pre- and syntectonic Paleogene). The two are separated by a detachment level located in marls materials and evaporitic materials from the middle and upper Triassic, and hence they develop more folds and thrusts, and their main characteristic is their plastic behaviour and incompetence.

Between the Oligocene and lower Miocene a new extensional process was produced that is framed within the context of the Western European rift system. The distension mainly affects the eastern margin of the Iberian Plate and causes a complex system of horsts and grabens, parallel to the Mediterranean coast, related to the formation of the Valencia trench (Fontboté et al., 1990; Rock and Guimerà, 1992). These sedimentary basins are limited by longitudinal faults

running NE-SW and NW-SE corresponding largely to the basement fractures reactivated during the compression of the Mesozoic and the extension of the lower Tertiary (Palaeogene).

III. SAMPLING INFORMATION

The soil samples belong to the Geochemical Atlas of Spain, produced by the IGME in 2012, which studies the geochemical components of soils and other superficial materials in the Spanish territory. A multi-element geochemical characterization of soils and superficial materials was performed. These geo-referenced data were introduced into a high-resolution geo-database.

a) Sampling methodology

- Composite stream sediments and residual soils at two depths (0-25 cm and 25-50 cm). A total of 14,000 sampling points (sediments + 2 soil depths). A total of 36,400 samples.
- Flooding plain sediments at two depths (top and bottom) in drainage basins with an area of 3000 to 6000 km². 332 sampling points are foreseen (664 samples).
- Supplementary data gathered at each hydrographic network and soil sampling point: pH and TOC.
- Three sampling densities were foreseen in the project, in accordance with the same number of great areas with higher or lower geological complexity, and industrial and demographic pressure (1 sample point/10 km², 1 sample point/20 km² and 1 sample point/100 km²). The spatial location of the sampling points is shown in Figure 3.

b) Sample Preparation and multi-element chemical analysis

- Sieving of sediments (150 microns), flood sediments (63 microns) and soils (2 mm).
- Total or almost total multi-element chemical analyses (63 elements) and with partial extraction (aqua regia) of samples by INAA, ICPAES and ICPMS. TOC determination.
- Analysis of organic pollutants (dioxins, pesticides, etc.) in agricultural zones, industrialized zones or areas with a high demographic density (1200 samples).

c) Quality control

- Quality control and sampling error determination (2 x 3.7% of field duplicates)
- Analytical quality control and analytical error determination (3.7% of duplicate samples)

This geochemical infrastructure complies with some basic requirements, derived from the recommendations of IGCP project 259 (Darnley et al., 2005) (IUGS-UNESCO). According to these requirements, sampling must satisfy the following requirements:

1. It should be based on samples of different media, which include soils (two depths), stream sediments, and floodplain sediments (2 depths). These later, in alluvial systems of a certain magnitude, will make it possible to determine the original uncontaminated values, prior to the industrialization period, and the variations that have taken place over time by comparison with present and future values.
2. It must be multi-element, including a wide range of chemical elements (63 in this case), comprising all those that are potentially dangerous for the ecosystem and those of any interest to geology and mineral resource research. They will be analysed by reliable techniques and with very low detection limits. Determination of the total or almost total contents and of the partial contents that will allow the easiest extractable or bio-available part to be estimated. This latter point is of particular interest for the environmental analysis and would allow an assessment of pollution processes to be carried out.
3. It should be available in digital form, to facilitate the integration of the geochemical information with other datasets (geology, metallogeny, land uses, animal or human morbidity and mortality).
4. It must be standardized across national boundaries, as many of the problems and concerns that arise regarding the surface make it necessary to go beyond the frontiers and perform analyses on a more global scale. The follow-up of the IGCP project 259 recommendations and the protocols derived from the FOREGS project entitled "Global Geochemical Baselines for Europe" will act as a guarantee for compliance with this requirement.

IV. DATA SETTING

Figure 3 shows the location of the sampling points. The study region covers an area of 20 x 30 km² and is located in the Iberian Plate, close to the Iberian Range and the Catalan Coastal Range, the east-central margin of the Iberian Peninsula in Spain.

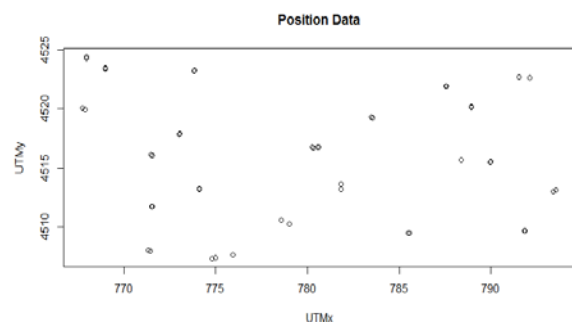


Figure 3: Beceite region with data points.

The data are distributed over a regular polygonal region, and the elements considered in our analysis are lithium, Al, K, Na, Ca, Mg, Fe, S, Mn, Ba,

Co, Ti, Zr, Nb, Ta, Ni, Cu, Pb, Zn, Sn, Rb, Cd, and Sb. Our goal is to analyse the concentration of lithium and its relationship with the concentration of the other elements considered in the study, considering those elements as covariates. The main objective is to assess how the covariates are related to the concentration of lithium in the study area and to assess which of such elements show a statistically significant relationship with lithium.

Figure 4 shows the histogram of lithium concentrations as well as a map showing the sampling locations and the observed lithium concentrations at each site. The data show a non-symmetric distribution with a shape that not resembles the normal distribution. It shows a Gamma distribution.

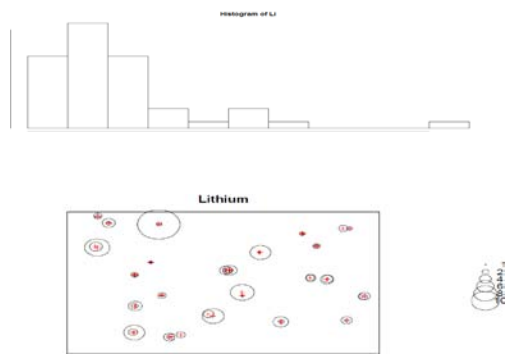


Figure 4: Top: Histogram of frequency of lithium;
Bottom: Distribution of lithium in the region.

V. METHODOLOGY STATISTICAL INFERENCE

The basic idea behind the Bayesian approach is that in any statistical model of a random phenomenon, only one source of uncertainty exists, which can be described by suitable probability distributions of model parameters (Box and Tiao, 1973). Thus, there is no fundamental distinction between observable data or unobservable parameters, which are also considered random-vector quantity θ .

The uncertainty about the value of the parameter vector before observing any data is described by a prior distribution $\pi(\theta)$. The inferential process combines the prior and the likelihood of observed data (x) given the model, to derive the posterior distribution $\pi(\theta | x)$, which is typically, but not necessarily, the objective of the inference (Bernardo and Smith, 2000; Lindley, 2006).

There are several advantages to the Bayesian approach: for instance the specification of prior distributions allows the formal inclusion of information that can be obtained through previous studies or from expert opinion; the (later) probability that a parameter does/does not exceed a certain threshold is easily obtained from the posterior distribution, thus providing a quantity that is more intuitive and interpretable than a

frequentist p-value. In addition, within the Bayesian approach, it is easy to specify a hierarchical structure on the data and/or parameters, which presents the added benefit of making predictions for new observations and missing-data imputation relatively straightforward.

a) Integrated Nested Laplace Approximation (INLA)

The Integrated Nested Laplace Approximation (INLA; Rue et al., 2009) approach has recently been developed as a computationally efficient alternative to more commonly known methods such as Markov Chain Monte Carlo (Gelfand and Smith, 1984, Wilks, 1996). INLA is designed for latent Gaussian models, a very wide and flexible class of models ranging from generalized linear mixed models (Breslow and Clayton, 1993) to spatial and spatio-temporal models. For this reason, INLA can be successfully used in a great variety of applications (e.g. Li et al., 2012; Riebler et al., 2012; Ruiz-Cardenas et al., 2012), thanks to the availability of an R package named R-INLA (Martino and Rue, 2010). Furthermore, INLA can be combined with the Stochastic Partial Differential Equation (SPDE) approach proposed by Lindgren et al. (2011) in order to implement spatial and spatio-temporal models for point-reference data.

b) The model

Let Y_j denote the observed data about lithium at specific points s_j , $j=1, \dots, 24$. Because $Y > 0$ for all s , we may consider that Y has a Gamma distribution. The Gamma distribution for lithium was chosen because the shape for the histogram for lithium concentrations suggested this was a sensible model for such data.

Given the positiveness of the values for lithium concentration, we consider the model:

$$y | F_y, \beta, x_i, \theta \sim \text{Gamma}(a_i, b_i)$$

$$\log(\mu_i) = F_i^T \beta + x_i \quad (1)$$

$$x_i \sim GF(0, \Sigma)$$

where F_i is a vector of covariates made by the concentration of the other elements considered in this study, β a vector of coefficients and x a latent Gaussian random field, with a covariance matrix function with parameters ν , κ and $\sigma \times 2$. With the Gamma likelihood, we consider that $E(y_i) = \mu_i = a_i / b_i$ and $V(y_i) = a_i / b_i^2 = \mu_i^2 / \phi$, where ϕ is a precision parameter and we define a linear predictor as $\log(\mu_i)$ (R-INLA, 2011).

In this case, for all the models, we obtained the parameters of the posterior distribution of the intercept (α), the dispersion parameter of the Gamma likelihood, the latent field parameters $\log(\kappa)$ and $\log(\tau)$, the fixed coefficients (β) for the covariates (Al, K, Na, Ca, Mg, Fe, S, Mn, Ba, Co, Ti, Zr, Nb, Ta, Ni, Cu, Pb, Zn, Sn, Rb, Cd, Sb) and the values of $(1/\sigma^2 e^2)$. The nominal variance and the nominal range (distance with correlation equal to 0.1) are also presented.

For the spatial covariance structure we used the Matérn family of covariance functions and a nugget term, over j .

$$\text{cov}(\varepsilon_j, \varepsilon_{j'}) = M(|j - j'|, r^2 \sigma^2, \rho, \nu) + (1 - r^2) \sigma^2 I(j = j') \quad (2)$$

M was the Matérn function (R-INLA, 2011); σ^2 denoted the sill (the total variance of the innovation process); $r^2 \sigma^2$ was the variance of the spatially correlated portion of the process; $(1 - r^2) \sigma^2$ corresponded to the nugget (the variability that is unique to a given station); ρ was the range of the process (the size of the region where the process was significantly correlated); and ν was the smoothness of the process (specifically, we tried $\nu=1$ for the model, R-INLA project). All the analyses were carried out with the freeware statistical package R (version 3.0.2) (Lindgren et al., 2011) and the R-INLA package.

c) *Stochastic Partial Differential Equation Approximation*

The SPDE approach allows a GF with the Matérn covariance function to be presented as a discretely indexed spatial random process (GMRF), which has significant computational advantages. Gaussian Fields are defined directly by their first- and second-order moments and their implementation is highly time-consuming and leads to the so-called “big n problem” (Lindgren et al., 2011). The idea is to construct a finite representation of a Matérn field by using a linear combination of basis functions defined in a triangulation of a given domain D . This representation leads to the SPDE approach given by (2), which is a link between the GF and the GMRF, and allows the spatio-temporal covariance function and the dense covariance matrix of a GF to be replaced with a neighbourhood structure and a sparse precision matrix, respectively, both of which are typical elements that define a GMRF. This, in turn, produces substantial computational advantages (Lindgren et al., 2011).

More particularly the SPDE approach consists in defining the continuously indexed Matérn GF $X(s)$ as a discrete indexed GMRF by means of a basis function representation defined on a triangulation of the domain D :

$$X(s) = \sum_{l=1}^n \varphi_l(s) \omega_l \quad (3)$$

where n is the total number of vertices in the triangulation; $\{\varphi_l(s)\}$ is the set of basis functions and $\{\omega_l\}$ are the zero-mean Gaussian distributed weights. The basis functions are not random, but rather are chosen to be piecewise linear on each triangle:

$$\varphi_l(s) = \begin{cases} 1 & \text{at vertex} \\ 0 & \text{elsewhere} \end{cases} \quad (4)$$

The key is to calculate $\{\omega_l\}$, which reports the value of the spatial field at each vertex of the triangle.

The values inside the triangle will be determined by linear interpolation (Simpson et al., 2011).

In our case, we obtain this representation of the mesh with the response variable, see Fig. 5.

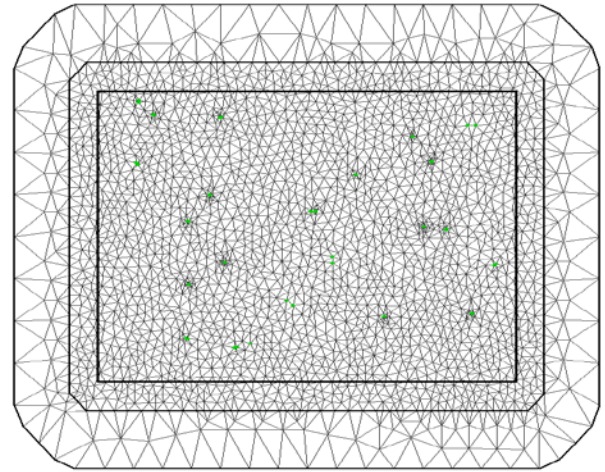


Figure 5: Triangulation mesh data for INLA.

We can see the relation between the data and the vertex for the implementation. This is the usual way of representing the regular region data when using INLA//to be able to use INLA.

VI. RESULTS

At this point, we know the data and the statistical framework and we have presented the statistical process with the applied study. First of all we can observe the advantage of this process because, in general, the processing time is long. In our case, the time needed for pre-processing: 8.2529 seconds, for running each INLA model: 3.4478 seconds, and for post-processing: 0.4212 seconds. We have produced many previous models but the one presented here is the final version used, with this processing time. In this study, different models have been tested. The first one (M1) includes only the spatial effect, the second one (M2) includes the spatial effect and the covariates (chemical elements) and, finally, the third one (M3) has only the covariates without the spatial effect. The basic structure in INLA for each model is:

M1 =
`inla(resp ~ 0 + m + f(i,model=spde5),family='gamma')`
 M2 =
`inla(resp~0 + m + f(i,model=spde5) + Al + K + Na + Ca + Mg + Fe + S + Mn + Ba + Co + Ti + Zr + Nb + Ta + Ni + Cu + Pb+Zn+Sn+Rb+Cd+Sb, family='gamma')`
 M3 =
`inla(resp~0+m+Al+K+Na+Ca+Mg+Fe+S+Mn+Ba + Co+Ti+Zr+Nb+Ta+Ni+Cu+Pb+Zn+Sn+Rb+Cd+ Sb,family='gamma')`

Now, the results of the model, the fixed effects, the random effects and the comparison between the real and the predicted data are presented.

Table I shows the mean, the standard deviation and the 2.5, 50 and 97.5 percentiles for the Intercept of the models (elements other than lithium).

a) *Fixed effects*

In our models, the fixed effects are presented by the covariates.

Table 1: Intercept coefficient of the models.

	mean	sd	0.025quant	0.5quant	0.975quant
M1	3.105	0.165	2.774	3.104	3.449
M2	1.065	1.312	-1.590	1.084	3.606
M3	0.322	1.233	-2.089	0.314	2.772

For the covariates, the fixed effects are presented in models M2 and M3 (in bold, the significative covariates).

Table 2 a: Fixed effects of the model M2. Mean, sd and 2.5, 50 and 97.5 percentil.

	mean	sd	0.025quan	0.5quant	0.975quant
Al	- 0.041	0.221	-0.476	-0.04	0.39
K	1.011	0.526	-0.022	1.008	2.06
Na	- 0.720	0.914	-2.574	-0.707	1.05
Ca	0.028	0.034	-0.038	0.027	0.09
Mg	-0.021	0.060	-0.138	-0.022	0.10
Fe	0.498	0.320	-0.135	0.498	1.13
S	3.894	4.014	-3.934	3.853	11.997
Mn	-0.000	0.001	-0.002	-0.0005	0.001
Ba	-0.0033	0.008	-0.019	-0.003	0.0129
Co	-0.064	0.053	-0.172	-0.063	0.040
Ti	3.500	3.670	-3.778	3.507	10.741
Zr	0.017	0.008	-0.0006	0.017	0.034
Nb	0.128	0.064	0.004	0.127	0.259
Ta	-1.957	0.905	-3.795	-1.942	-0.207
Ni	0.023	0.034	-0.043	0.023	0.091
Cu	0.005	0.004	-0.004	0.005	0.014
Pb	0.011	0.011	-0.010	0.011	0.033
Zn	0.007	0.008	-0.008	0.007	0.024
Sn	-0.126	0.146	-0.419	-0.126	0.161
Rb	-0.012	0.014	-0.041	0.012	0.016
Cd	-0.050	0.920	-1.883	-0.047	1.760
Sb	-0.708	0.568	-1.832	-0.709	0.415

Table 2 b: Fixed effects of the model M3. Mean, sd and 2.5, 50 and 97.5 percentil.

	mean	sd	0.025quan	0.5quant	0.975quant
Al	0.011	0.214	-0.409	0.0113	0.435
K	1.156	0.500	0.177	1.152	2.153
Na	-1.051	0.925	-2.858	-1.057	0.791
Ca	0.047	0.033	-0.018	0.047	0.113
Mg	0.021	0.054	-0.085	0.021	0.128
Fe	0.490	0.311	-0.121	0.489	1.105
S	5.401	3.924	-2.256	5.372	13.220957
Mn	-0.0001	0.001	-0.002	-0.0001	0.002
Ba	-0.002	0.008	-0.018	-0.002	0.013
Co	-0.103	0.047	-0.197	-0.103	-0.009
Ti	4.833	3.303	-1.702	4.839	11.323
Zr	0.013	0.008	-0.004	0.013	0.030
Nb	0.156	0.064	0.029	0.156	0.283
Ta	-2.387	0.905	-4.163	-2.390	-0.594
Ni	0.043	0.029	-0.015	0.0438	0.102

Cu	0.003	0.004	-0.005	0.003	0.012
Pb	0.012	0.010	-0.008	0.0121	0.033
Zn	0.004	0.008	-0.011	0.0046	0.020
Sn	-0.184	0.140	-0.460	- 0.185	0.094
Rb	-0.015	0.015	-0.045	- 0.015	0.013
Cd	-0.393	0.842	-2.050	- 0.395	1.270
Sb	-0.754	0.528	-1.798	- 0.754	0.285

In Tables IIa and IIb, we can see positive values for the elements that increase the value of lithium and the negative values for the elements that decrease the amount of lithium. But the most important thing is to check which one has a significant statistical effect.

For Model M2, we can see that only Nb offers a significant result and Zr, Ta, Cu, Pb, Zn and Rb are elements close to being representative in the study of lithium.

For Model M3, we can see that K and Nb are positively significant in the study of lithium and Ta is significant in the opposite way.

b) Random effects

In this case, the hyperparameters correspond to the Gamma distribution and, since we do not know the values (Bayesian inference), they could be compared with the posterior. We have only the structure. In this case, the parameters are $1/\sigma^2$ or marginal variance nominal, marginal kappa and marginal range nominal.

MODEL 1

$1/\sigma^2$: 2.229

Marginal kappa: 2.259296

Marginal variance nominal: 0.09013456

Marginal range nominal: 5.123559

MODEL 2

$1/\sigma^2$: 27.419

Marginal kappa: 3.54715

Marginal variance nominal: 0.08050951

Marginal range nominal: 2.273834

If we want to know the form of the structure of the parameters, they can be seen in Fig. 6.

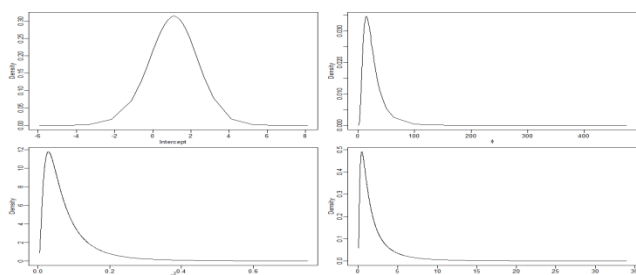


Figure 6: Marginal distribution of the parameters of M2.

For M3, the parameter associated to the Gamma likelihood has a value of 10.7411 with a standard deviation of 2.8977.

We can see the structure of this parameter in Fig. 7 below.

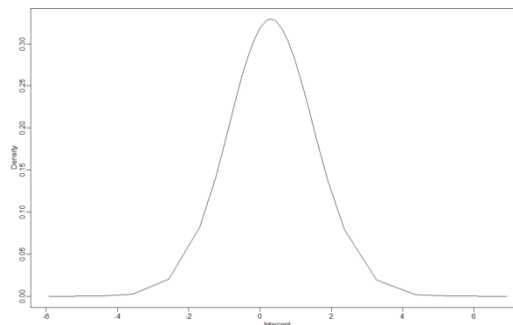


Figure 7: Marginal distribution of the parameters of M3.

Finally, in this section we can compare the Deviance Information Criterion (DIC) of the three models, where the best one is clearly the complete one, i.e. M2 (the lowest DIC value).

M1: 379.7338; M2: 286.9914; M3: 317.1496

Comparison of observed vs. predicted values and computed residuals in the same positions.

Fig. 8 shows the relation between the observed and the predicted values for the three models. The results are clearly optimum in the second one, M2. In Table III we can also see the results for the correlation coefficients and for the root-mean-square error (RMSE). In the same way, the results are satisfactory and the best model is the second one (M2).

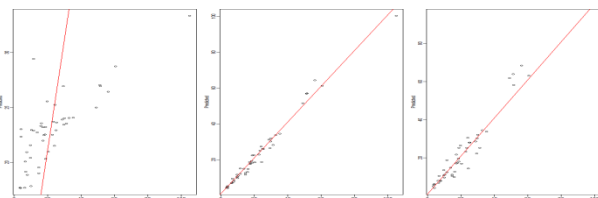


Figure 8: Correlation between Observed and Predicted values for 3 models, M1, M2 and M3.

Table 3: Correlation and RMSE for each model analyzed.

Model	Correlation coefficient	RMSE
M1	0.7833763	16.17654
M2	0.9909199	2.59907
M3	0.9667658	5.061028

c) Prediction Map

Finally, we can see the prediction maps of the latent field and the response variable for M1, with the corresponding standard deviation and the response variable for M2 (Fig. 9-11). As an example of the application of this methodology the reader is referred to Jordan et al. (2004).

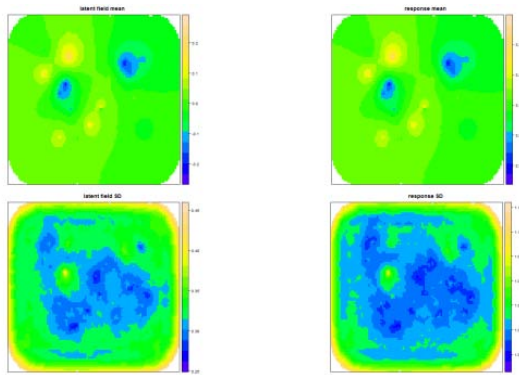


Figure 9: Prediction maps of M1. Top-left the latent field mean, the top-right the response variable mean, the down-left the latent field sd and down-right the response variable sd.

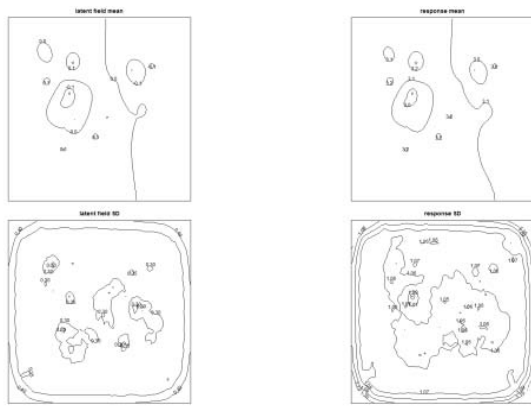


Figure 10: Contour prediction maps of M1. Top-left the latent field mean, the top-right the response variable mean, the down-left the latent field sd and down-right the response variable sd.

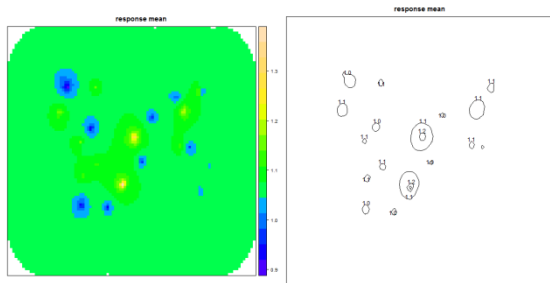


Figure 11: M2 in both cases. Left: Response variable mean. Right: Contour of response variable mean.

In all cases, the highest predicted values of lithium under these conditions are found for the North of the Beceite area.

VII. DISCUSSION AND CONCLUSION

This work presents the predicted values of lithium in the study region. They were obtained with a new methodology in Bayesian probabilities called INLA. The results showed that the lithium values could be studied by knowing the different covariates.

Henceforth, from the results of the model with the fixed effects, the random effects, and the comparison between real and predicted data it is possible to appreciate that lithium does not increase or decrease its concentration noticeably with any other element. On the one hand, if model 2 (M2), which fits the data better, is taken as a reference, at most it is possible to appreciate a slight increase in niobium and a minor decrease in thallium. On the other hand, model 3 (M3) showed an increase in potassium and niobium, and lithium decreased in the presence of thallium. Lithium might have been expected to connect with some specific geological materials of the area, such as clay minerals, with an important Al and K content and to a lesser extent Fe. It formed part of clay minerals, frequently appearing mixed with sandstones. In relation with the age of the materials, lithium was related mostly to Lower Cretaceous and Tertiary deposits, which cover an important surface area of the region, second to colluvial and alluvial Quaternary materials, and finally, to a much lesser extent, to Triassic formations.

In this study, we have focused in the content of Lithium at soils and sediments in relation to several elements, especially heavy metals, in order to determine its geogenic presence through the INLA modelization, taking into account that Lithium shows different geochemistry in different origin deposits, especially marine, as the main studied area.

Finally, regardless the results, the use of the model could provide new insights in order to face other geochemist studies in soils and sediments for environment, agrarian, or mining prospectations.

As we known, Lithium presents many important uses and applications such as: ceramics and glass, electrical and electronics standing out lithium ion batteries, as well as a lubricator for greases, in metallurgy, pyrotechnics, air purification, optics, organic and polymer chemistry, and medicine. For all of these applications, the results we got for predicting the quantity and the location of Lithium it should be taken into account.

On the other hand, the phyllosilicates would contain potassium and would not appear with sodium clays. Furthermore, lithium would not be related with brines, for instance the marine Keuper deposits represented in the area, which contain sulphate and chlorine minerals (Fig. 12).

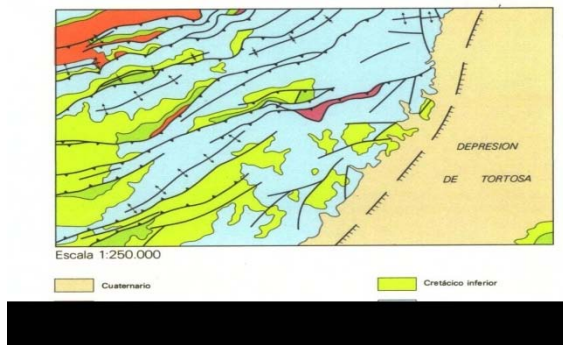


Figure 12: Tectonic map of the Beceite area in the Iberian Range and Catalan Coastal Range (IGME, 1985).

All in all, the geological context was defined during the Late Jurassic to Early Cretaceous rift stage, where several sub-basins were developed (in the Spanish provinces of Castelló, Teruel and Tarragona), which were filled by fluvial to transitional sandstones and lacustrine carbonates (Weald facies), later evolving to marine limestones (Urgon facies). These sub-basins trapped clastic sediments from the Tertiary, where potential source areas are metamorphic and pre-rift Triassic and Jurassic sedimentary cover rocks.

In summary, the most important idea is that the presence of a geological element in a region could be predicted when we know the others using the INLA procedure for the statistical inference, which is faster than the use of MCMC techniques.

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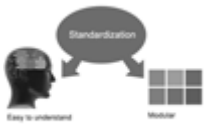




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1. General,
2. Ethical Guidelines,
3. Submission of Manuscripts,
4. Manuscript's Category,
5. Structure and Format of Manuscript,
6. After Acceptance.

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- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently. You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.



Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.



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<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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