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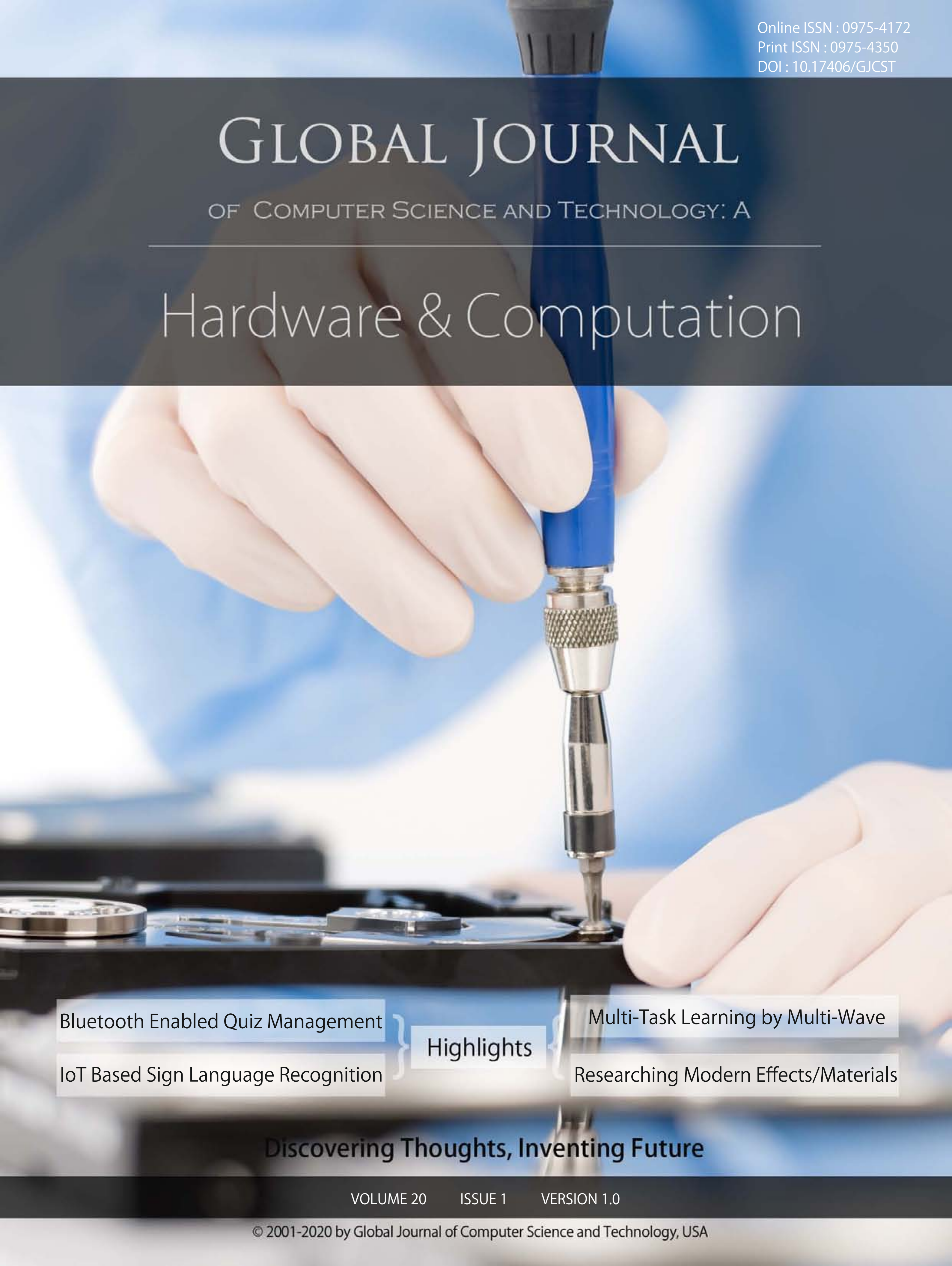

Highlights

- Bluetooth Enabled Quiz Management
- IoT Based Sign Language Recognition
- Multi-Task Learning by Multi-Wave
- Researching Modern Effects/Materials

Discovering Thoughts, Inventing Future

VOLUME 20 ISSUE 1 VERSION 1.0

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An Approach to Establishing Simultaneous Server-Side Connections for NFC/Bluetooth Enabled Quiz Management Systems

By Jedidiah Aqui & Michael Hosein
University of the West Indies

Abstract- Near Field Communication is a set of communication protocols for communication between two electronic devices over a distance of 4cm or less and Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using UHF radio waves in the industrial, scientific and medical radio bands, from 2.402 GHz to 2.480GHz, and building personal area networks(PANs). Both these protocols facilitate wireless/ internet less communication between devices that have the capabilities. This paper seeks to further expand the concept and usage of these protocols via the examination of modifications made to a Quiz Management System. The Quiz Management System, which is a solution to further advance the notion of a smart classroom setup within the context of short-range wireless technologies has already seen iterations developed on both the NFC and Bluetooth side of things.

Keywords: quiz management system, smart classroom, protocol, bluetooth, NFC, UHF.

GJCST-A Classification: C.2.1

ANAPPROACHTOESTABLISHINGSIMULTANEOUSSERVERSIDECONNECTIONSFORNFCBLUETOOTHENABLEDQUIZMANAGEMENTSYSTEMS

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An Approach to Establishing Simultaneous Server-Side Connections for NFC/Bluetooth Enabled Quiz Management Systems

Jedidiah Aqui [α] & Michael Hosein [σ]

Abstract- Near Field Communication is a set of communication protocols for communication between two electronic devices over a distance of 4cm or less and Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using UHF radio waves in the industrial, scientific and medical radio bands, from 2.402 GHz to 2.480GHz, and building personal area networks(PANs). Both these protocols facilitate wireless/ internet less communication between devices that have the capabilities. This paper seeks to further expand the concept and usage of these protocols via the examination of modifications made to a Quiz Management System. The Quiz Management System, which is a solution to further advance the notion of a smart classroom setup within the context of short-range wireless technologies has already seen iterations developed on both the NFC and Bluetooth side of things. The QMS will be further developed to address a key limitation that was observed. That is the inability to facilitate multiple server-side connections to client devices beyond the established limit of the existing model (limit being 5 simultaneous connections at a time). This is important due to the fact that, in addressing this limitation, the adoptability and feasibility of this system would grow substantially as persons utilizing the system would not be impeded by the inefficiencies of having to walk and connect to a single device at a time or five (5) devices (maximum) at a time within a university classroom setting, and by 'university classroom' setting, one could imagine a setup such as a class of over two hundred(200+) students.

Keywords: quiz management system, smart classroom, protocol, bluetooth, NFC, UHF.

I. Introduction

With the advent of a global pandemic, societies at large have witnessed the shutting down of numerous institutions of gathering and socializing. Many of those institutions consist of churches, sporting events, entertainment events, schools, etcetera. In light of these shutdowns, governments the world over, were forced to adapt and facilitate numerous activities that were once viewed as "in person" or "attendance mandatory" activities via the internet and its many online portals. The area in which this project seeks to primarily address, is the educational institutions (Schools).

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The use of online classes is not a new topic of discussion or concept as far as technological advances in the educational sphere is concerned. Numerous papers and contributions have been made with respect to online classes/sessions (Kulkarni et al., 2013 and Frydenberg, 2007) and (Grandon, Alshare, and Kwun,2005).Additionally, what is quite notable in the midst of an ongoing pandemic is the vast migration of many institutions to the use of Online platforms to host their classes, meetings, seminars etcetera. The fast-paced transformation of these institutions to technological platforms all encompass aspects of what is being termed the "new normal". But one must also take into consideration the latter phases of the "new normal", which would encompass a steady and careful re-engagement of the former way of life at least to a substantial extent. With a re-engagement of the former, one can expect institutions of learning to begin the process of re-opening and facilitating in-person knowledge transfer activities such as classes, lectures, tutorials, etcetera as safely as possible. With safety being of paramount priority, one can expect all necessary guidelines as far as social distancing dictates, to be enforced.

To address the adaptation to the latter phase of the "new normal" the option of a smart classroom approach would be explored and further elaborated upon. (According to Shalini, December 2018) A smart classroom is where the concept of blended learning is considered to be blooming, it isa technologically enhanced environment that enables teaching and learning opportunities on a different level. Within the context of a smart classroom, the use of the Quiz Management System(QMS) would come into play. To generalize, the QMS is a system that is geared towards facilitating the distribution of quizzes and/or quiz material by the teacher(server) as well as subsequent retrieval of quiz material by students (clients) for grading and redistribution.

The QMS itself is a step in the right direction as it brings the notion of leveraging Bluetooth/NFC technology to further promote or simulate a smart-classroom setup. The QMS captured functionality that allowed students to submit their work and review the marked material and it also allowed the teachers(server)to select the quiz material to distribute, collect the quiz material for marking and perform analytics on the data obtained before subsequently distributing the marked material. Its merits cannot be overlooked as it fostered contactless communication from client to server devices and vice versa. However, there were some limitations in the developed model that were noted.

A key limitation of the QMS was its inability to support a large number of simultaneous connections on the server side. Consider the work done by (M.Hosein and L.Bigram, 2013). Theirs was a Bluetooth Quizzing Application in Android called Blue Q. The developed application was able to simulate much of the QMS's core functionality via the use of the Bluetooth protocol, however it was only able to facilitate simultaneous connections to a maximum of 5 devices, the authors further postulate that future work on the developed application could entail the supporting of more simultaneously Bluetooth connections on the server side. Additionally, in the studies done by (Mohammed Salah Abood, Mahamod Ismail, and RosdiadeeNordin, 2017). The authors were able to develop and further add to the work of the Bluetooth application formerly mentioned by utilizing XML to structure messages passed between both client and server. Furthermore, in their work, the authors developed a solution using Near Field Communication Technology (NFC) as the main protocol for transferring information from Client(student) to Server(Teacher). However as was the case in the first iteration of the application, this was also a system developed on the basis of one to one communication between Client and Server devices.

This problem can further be grasped by adding some context. For example, if the QMS was to deployed in a classroom of 5-6 persons, sharing course content to students and also receiving course content/solutions from students(client), would be considered a relatively simple task that can be performed in a short timeframe, however in the context of a University classroom that may house well over 100-200+ students in a session. Distributing course contents(quizzes) and receiving student feedback can pose quite a challenge, as one must now consider the amount of time it takes to fully conduct this activity from the Server to each individual Client, given that there are no anomalies to hinder the process with each student.

An additional level of analysis is also required in establishing which of the two protocols (NFC or Bluetooth) should the testing of multiple server-side connections be executed with. In retrospect, whilst these developed models did in fact have a substantial impact in promoting a smart classroom setup using Bluetooth and NFC technology, the identified gaps would serve as an indication as to the slow adoption of the "smart-classroom" concept which sees the utilization of these protocols for distributing information. It is not so much so as to how to develop NFC/Bluetooth solutions to compliment the idea of a smart classroom setup, but is a matter of how do we increase the efficiency and practicality of these systems to gain further support from Universities the world over, in the midst of a pandemic. This project entails the resolution of these core problems as an iterative step to the already developed Quiz management system. By addressing these problems, the feasibility of a safe smart classroom environment in the "new normal" period can be further bolstered and gain support.

II. Literature Review

In This Chapter, we would not only be exploring the research work and implementations conducted as it relates to similar quizzing applications. But we will also be exploring the work done as it pertains to the concepts of Bluetooth connections to multiple devices as well as identify the merits and limitations of each of the discussed material.

(Mohammed, Mahamod, and Nordin, 2016) presented an NFC-based classroom tool known as the 'Quiz management system'. The solution (QMS) was able to further advance the notion of a smart classroom setup within the context of short-range wireless technologies. As it pertains to this system, one would recognize the function of two key actors, one being the Student (Client) and the other being the Server(Teacher).For the sake of simplicity we would refer to the Student/Client device as Participant1 and the Server/teacher device as Participant 2. The core functions of each actor are as follows:

Participant 1: Is the Client/Student who would do the requesting of quizzes as well as the submission of quizzes for correction.

The key activities are captured in the below bullet point listing

1. Interacting with the UI of the application
2. Quiz handout activity
3. Answer Collection Activity
4. Quiz Submission Activity
5. Results Activity

Participant 2: Is the Server/Teacher who would be responsible for distributing the quizzes via his/her interface. The Server/Teacher would also be privy to additional functionality as opposed to the client and thus, can be viewed as a super-user within the context of the system.

The key activities are captured in the below bullet point listing

1. Interacting with the UI of the application
2. Input activity
3. Quiz reception activity
4. Quiz performance activity
5. Answer submission activity

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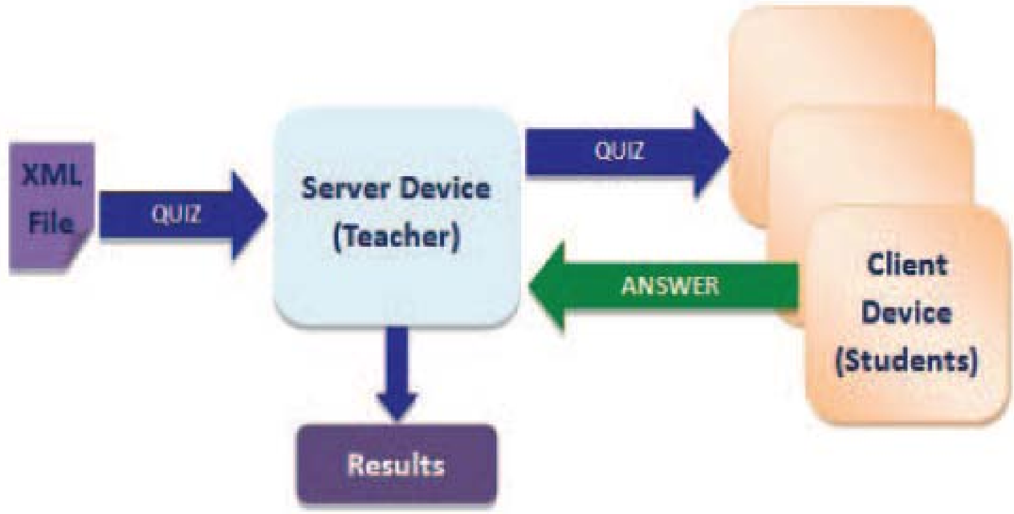
The roles of 'Participant 1' and 'Participant 1' can now be observed within the context of the QMS System via the below general architecture diagram in (Figure 2.1):



Another system was also developed by (Michael and Laura, 2013) which was a Bluetooth quizzing application for the android platform was developed. This system was quite similar to the formerly mentioned NFC solution with one of the major differences being the choice of protocol for communication and sharing of data. The protocol utilized was the Bluetooth protocol. The designed solution addresses the below problems directly:

1. Low attendance rate
2. Low pass rates
3. Poor Learning curve of students
4. Time consuming nature of a paper-based quizzing system

The solution Blue Q consisted of 2 main components, which were the 'Server Side' and the 'Client Side' these components were implemented on the Android Operating System. The proposed system encompassed several key functions/features to facilitate the distribution and receiving of course content (quiz material). The core functions are as follows:

1. Start Server – This function involved starting the server
2. Manager – This function involved the creation and editing of new courses, quizzes and students
3. Data Analysis - This function involved analysis of submitted quiz material
4. Exit

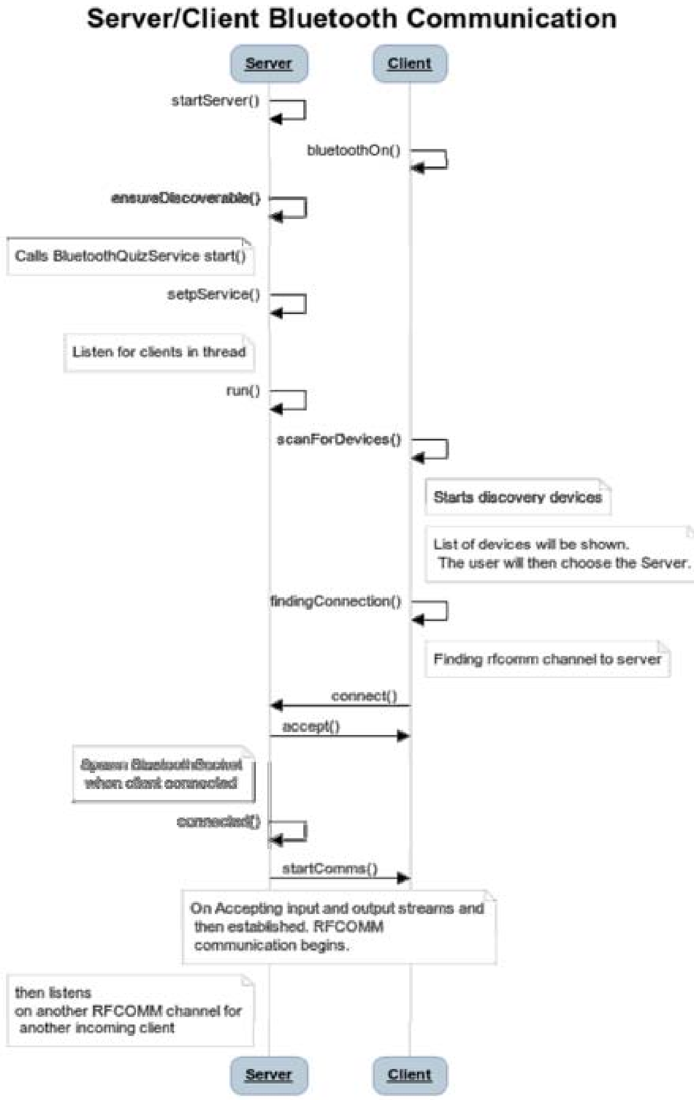


Figure 3: Showing the Core functions sequence diagram of the Blue Q quizzing solution

In the work of (Brian, 2014) a low-level vantage point of establishing Bluetooth connections amongst android devices is explored and segments of code provided to further solidify the concepts. This paper was able to shed light on many of the concepts that were required for developing our solution as well as the limitations of the selected protocol for communicating data(Bluetooth).The author postulates that the Android device will be communicating with a Bluetooth module connected to an Arduino Uno microcontroller as shown in Figure 4 below. The author focused primarily on the establishment of Bluetooth connections between two devices and delved further into the issues commonly experienced throughout the process of turning on Bluetooth, establishing a connection between devices, multi-threading and transferring data.

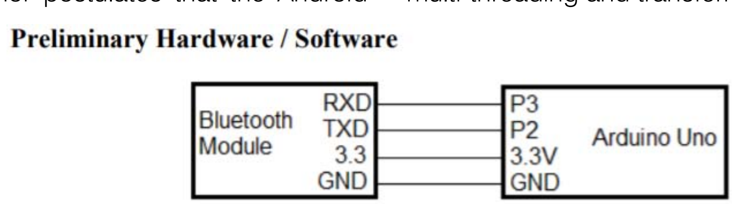


Figure 4: Showing Bluetooth Module – Arduino Uno Connectivity

Another paper done by (Naser Hossein, Motlagh (May 2012)) focused on a technical overview of Near Field communication technologies. The overview covered multiple aspects of the emergent NFC technology such as: 'Introduction to wireless communication', 'RFID technology overview', 'Physical Principles and Electromagnetism', 'Radio Frequency and Data transmission', 'NFC Applications' and 'NFC

Security'. Pertaining to work done with respect to NFC applications, aspects of NFC that were currently being applied in the field of short-range applications were highlighted. The focus was made to the usage of NFC chips with mobile phones. In the work done, the author made mention of the three main operating models of NFC, with the primary focus in the interest of this paper, being related to the "peer to peer communication" operating model(O.M.). It was noted that in this O.M. only two devices at a time could have exchanged the data at the link layer level.

And finally, in the work done by (Zimbric, Oct 2012) the focus was on pairing multiple devices to a Bluetooth accessory. The concept was very similar to the work done on this thesis however, the approach was very different as pairing was done based on device profiles for example 'hand-held' device or 'wireless headphones'. Furthermore, this approach primarily focused on the Bluetooth accessory as opposed to the device in which it would have been interacting with. The goal was to have the accessory connected to two devices at a time where by functions could have been executed.

III. Application Details

There were 3 main approaches employed in the proposed solution to solve the initially identified problems. They are detailed below:

Approach 1: Version 2 (multi-channel - Identical UUIDs) This approach explored the route of adding additional RFCOMM channels that are associated with the same UUID. It mimicked the concepts of Client/Server TCP/UDP communications (Lei Wang et al.,2000)having the server socket wait for connection from a client socket, whilst a listening socket is activated for receiving new connections and mapping unto the server socket. In this concept, if we were to assign maximum of2 channels per UUID, we would accomplish simultaneous connections for data transfer to 2 x 8 client devices at a time. The below Sequence Diagram Shows the flow of events in Approach 1- Version 2:

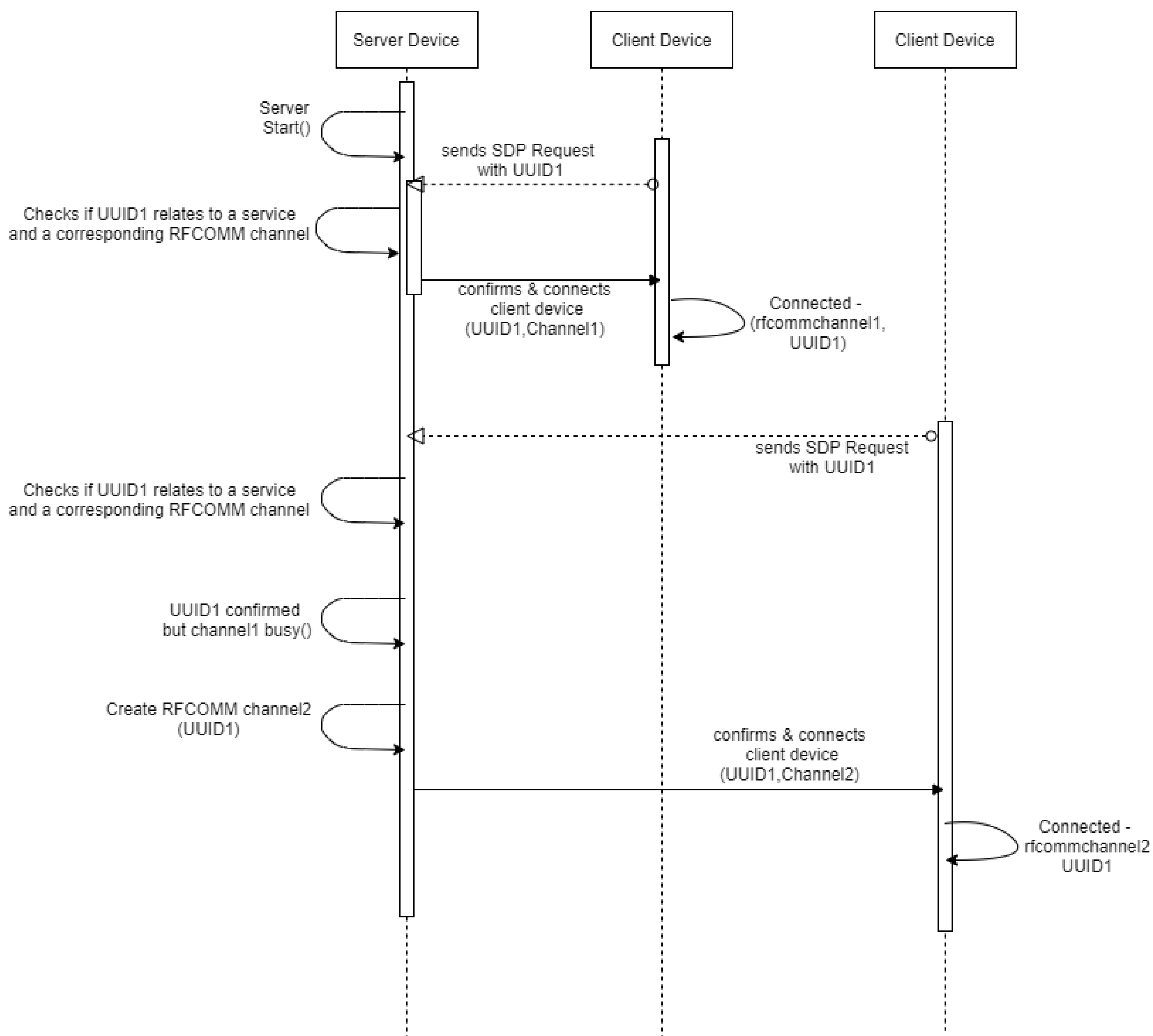


Figure 5: Sequence Diagram - Approach1 Version2

By merit of how RFCOMM works it is stated that it would support a total of 60 simultaneous connections based on the UUIDs assigned to each of those channels. This UUID is what the client uses to firstly identify the channel it wishes to connect to via its SDP call, then a connection is established, but since RFCOMM is a serial communication protocol, it would only allow 1 connection at a time per channel, there is no multiplexing unless you switch from a serial protocol to a parallel protocol. Going further into this, the proposed modification could see the sharing of UUIDs for 2 channels at a time, 2 channels being the upper limit. Given that all the necessary provisions are made available, and the user has the optimum storage and processing power to host 60simultaneous connections, this method of dual channeling per UUID could possibly push the amount of simultaneous connections to "120"total. Now this is of course the perceived amount of simultaneous connections, however it would still be recorded as 60, since half the figure represents Unique (UUIDs) and the other a replication.

But that is observing from a holistic point of view in accordance with the protocol's specifications. As we apply this logic to the presented solution, we can now seek to address the inefficiency of having limited amount of channels used at any given time for material to be distributed by the server device or submitted by the client device. Consider the current application's limit of 8 channels per server device. That alludes to the point that there are 8 UUIDs that are hardcoded into the low-level code of the server device by which the RFCOMM channels can be accessed by. The solution being proposed now assigns a total of 2 channels per UUID. This therefore raises the amount of allowable connections to the server by +8 giving a total of 16 connections at a time per server device. The below figure shows the results of sharing UUIDs as more than the maximum limit of 8 devices were able to connect.

Figure 6: Sharing UUIDs - Approach1 Version2

Approach 1 - Version 3 (queuing)

If in its strictest sense the server device must maintain 8 channels irrespective of UUIDs. Then a queue for each channel with an allocation of 1 allotment for a client device would be established, since the UUID would refer to the channel number in which the service is being provided, the queue would be able to guarantee that a connection has already been made with the channel, however it is currently in use and thus, once completed it will become available.

This guarantee stands on the basis that based on the UUID both the client devices would be treated as one device attempting to access the same service. However, it would all come down to which device connects first. Connecting to the server first would be based on which of the 2 devices is nearer, with the device closest, being successful in connecting to the channel and being able to access the channel and the device furthest from the server being successful in connecting to the server but placed into queue. The below figure shows the results of queuing clients with the samw UUID.

Figure 7: Sharing UUIDs and queuing- Approach1 Version3

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This functionality ensures that the client will receive the quiz content without having to re-attempt connecting to the server multiple times. Thus, this method is a viable option for improving the efficiency of Approach 1.

Approach 2 - Delegate Function()

Approach 2: Given that the server device is mainly responsible for the distribution of quizzing materials and can only supply material to up to 8 devices at a time. The proposed solution would see the modification of the existing system to include the 'delegation' functionality. The delegation functionality works as such: Server Device connects to 8/100 devices at a time, given that the assumed sample/classroom size is 100 students. Then in an effort to increase the efficiency of the system, the Server device can select one of the connected client devices and elevate their privileges or rather give/delegate new functionality to allow the distribution of quiz material. Assuming that the selected client device is able to support the same amount of connections as the server device, this therefore means that a total of 16/100 devices can connect to receive quiz material at a time. If the number of client devices 'n' that is given Server privileges increases, then the rate in which quiz material can be distributed would take on the form of an exponential curve, thereby increasing the efficiency of the Bluetooth quizzing system.

This approach when compared to the first approach has some immediate advantages: It does not affect the performance of the original hosting device but rather acts as an extension of its functions. What must be taken into consideration is the UUID generator function in which random UUIDs are generated and are hardcoded as the UUID's assigned to the available channels for clients to access their services. This method must ensure that the function delegate() is triggered upon the original Server Device selection of the option to Delegate. As it is an extension of Blue q the interface would consist of the below options.

1. Start Server
2. Manager
3. Data Analytics
4. Delegate
5. Exit

In theory this additional functionality can be likened unto a wi-fi peerto peer network as was postulated by developer.android.com, October2020. It is important to recall that the core concept of a peer-to-peer network is to partition tasks or workloads between pairs. In this concept peers are equally privileged, similar to the work done by (SewookJung et al., 2007). However, in this modification of the system, the server device, determines the functions to send to the client device and thus plays an integral role in determining the amount of privileges a selected client device is afforded.

The below Sequence Diagram Shows the flow of events in Approach 1- Version 2:

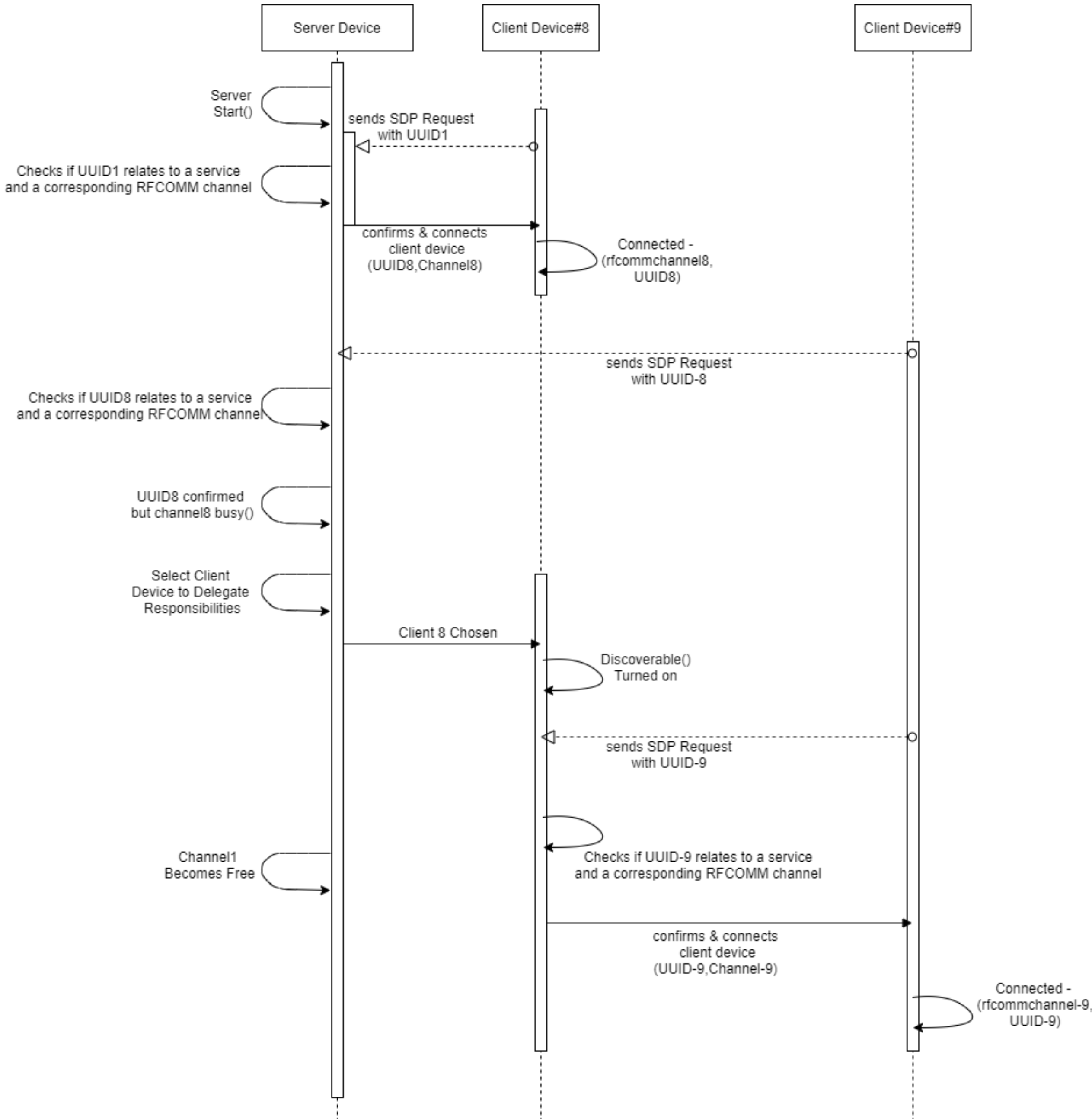

Figure 8: Sequence Diagram – Approach2

IV. Modeling and Testing

This section presents the results of the testing models implemented and gives an indication as to their individual sample sizes and overall performance against the previous QMS known as Blue Q with respect to simultaneous connections being enabled:

Approach1 version 2 (Shared UUID and multi RFCOMM Channels)

- Total Amount of devices tested = 16 devices
- Total Amount of devices that can be supported in an instance = 16 devices
- Average Device Connect Time/s = 2.403s
- Total Connection Time/s = 38.45s

Approach1 version 3(Shared UUID and RFCOMM channel queuing)

- Total Amount of devices tested = 16 devices
- Total Amount of devices that can be supported in an instance = 16 devices
- Average Device Connect Time/s = 2.403s
- Total Connection Time/s = 38.45s

Approach 2 (Delegate function)

- Total Amount of devices tested = 16 devices
- Total Amount of devices that can be supported in an instance = 64 devices
- Average Device Connect Time/s = 2.329
- Total Connection Time/s = 20

Previous QMS(BlueQ)

- Total Amount of devices tested = 5 devices
- Total Amount of devices that can be supported in an instance = 5 devices
- Average Device Connect Time/s = 2.38
- Total Connection Time/s = 37.3s

From the above results it can be observed that whilst all approaches when compared to the previous QMS did offer more simultaneous connections, the 'Delegate' approach proved to be the most efficient and scalable method as it was able to support a far greater number of simultaneous connections within approximately the same time as the other proposed solutions. A total of 64 connections versus 16 connections of the other approaches can be supported by the 'Delegate' approach.

Approaches	Total Amount devices that can be supported in an instance	Average Device Connect Time/s	Total Connection Times/s	Total Amount devices that can be supported
Approach 1 Version 2 - (Shared UUIDs and Multi RFCOMM	16	2.403	38.45	16
Approach 1 Version 3 - (Shared UUIDs and RFCOMM channel	16	2.674	111.78	16
Approach 2 - Delegate	64	2.329	20	64
Previous System - Blue Q	5	2.38	37.3	5

Figure 9: Testing Model Results for all systems:

A further breakdown on the testing methodology, results and technical analysis can be viewed in the conference paper: "A Technical review of the testing methodologies for QMS Simultaneous Server-Side connections"

V. Conclusion

In Conclusion, three solutions/approaches were developed and implemented to solve the problem of lack of popularity or usage of Bluetooth/NFC Quizzing systems within the context of a University Ambient.

These three solutions, saw the usage of the concepts of sharing UUIDs to achieve a greater level of connectivity to the server device as well as the concept of delegating responsibilities from the server device to the client device in an effort to distribute channel sharing load, thus making even more RFCOMM channels available and elevating the privileges of selected clients.

The test results of all approaches were reviewed in an effort to gauge the performance of each of the proposed and developed approaches versus the previous BlueQ system. From the stated results it was shown that the delegate approach proved to be the most meritorious in terms of performance and scalability when compared to the other implemented approaches.

Some of the future work of this paper, would see a similar implementation with the usage of the NFC Protocol. It would also see further work being done in attempting to make the modified QMS a cross-platform entity and not only an 'android specific' solution. Additional work can also be done to further the security aspects surrounding the sharing of UUIDs

References Références Referencias

1. Ajay, Goyal (May 2019). "NFC vs. Bluetooth: A Detailed Comparison". In: endivesoftware.com.
2. Aneesh, R, B Sreekumari., and K Jiju (Dec 2012). "Design and implementation of Bluetooth MAC core with RFCOMM on FPGA".
3. Brian, Wirsing (2014). "Sending and Receiving Data via Bluetooth with an Android Device". Bär, Henning, Guido Rößling, Erik Tews, and Elmar Lecher. 2006.
4. Davidrajuh, Reggie (January 2009). "Evaluating performance of a Bluetooth based classroom tool". In: International Journal of Mobile Learning and Organization.
5. developer.android.com (October 2020). "Create P2P connections with Wi-Fi Direct".
6. Frydenberg, Jia (2007). "Persistence in University Continuing Education Online Classes". In: he International Review of Research in Open and Distributed Learning 8.3.
7. Grandon, Elizabeth E., Khaled Alshare, and Obyung Kwun (Apr. 2005). "Factors Influencing Student Intention to Adopt Online Classes: A Cross-Cultural Study". In: J. Comput. Sci. Coll. 20.4, 46–56. ISSN: 1937-4771.
8. Hongwei, Du (2013). "NFC Technology: Today and Tomorrow". In: International Journal of Future Computer and Communication 2.4.
9. Ken, Schwaber and Sutherland Jeff (2013). "What is Scrum?"
10. Kulkarni, Chinmay et al. (Dec. 2013). "Peer and Self Assessment in Massive Online Classes". In: ACM Trans. Comput.-Hum. Interact. 20.6. ISSN: 1073-0516.
11. Lei Wang et al. (2000). "Multipath source routing in wireless ad hoc networks".In: 2000 Canadian Conference on Electrical and Computer Engineering. Conference Proceedings. Navigating to a New Era (Cat. No.00TH8492).Vol. 1, 479–483 vol.1.

12. McDermott-Wells, P. (2005). "Bluetooth scatternet models". In: IEEE Potentials23.5, pp. 36–39.
13. Michael, Hosein and Bigram Laura (2013). "An Educational Bluetooth Quizzing Application in Android". In: International Journal of Wireless Mobile Networks(IJWMN) 5.6.
14. Miklos, G. et al. (2000). "Performance aspects of Bluetooth scatternet formation". In: 2000 First Annual Workshop on Mobile and Ad Hoc Networking and Computing. MobiHOC (Cat. No.00EX444), pp. 147–148.
15. Mohammed, Salah Abood, Ismail Mahamod, and Rosdiadee Nordin (2016)."A Quiz Management System Based on P2P Near- Field Communication On Android Platform for Smart Class Environments".
16. Naser Hossein, Motlagh (May 2012). "Near Field Communication (NFC) A Technical Overview". In: University of Vasa Faculty of Technology Telecommunication Engeineering - Research Gate.
17. Robert, Triggs (June 2019). "What is NFC and how does it work". In: androidauthority.com.
18. Sewook Jung et al. (2007). "Pervasive and Mobile Computing". In: vol. 3. 6,609–634 vol.3.
19. Shalini, Khemka (December 2018). "What's a Smart Classroom and Why Do You Need It?"
20. Sneh Ratna, Choudhary (March 2020). "Phones compatible with NFC in 2019".
21. Zimbric Frederick J. (Gurnee, IL US) Walsh Michael G. (Johnsburg IL US) Adams Jr. Mark Graham (Hoschton GA US) (Oct 2012). "Methods and Devices for automatic multiple paring of Bluetooth devices".

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Why do we need to Introduce Temporal Behavior in both Modern Science and Modern Computing, With an Outlook to Researching Modern Effects/Materials and Technologies

By Janos Vegh
Kalimanos BT

Abstract- Classic science seemed to be completed more than a century ago, facing only a few (but growing number of!) unexplained issues. Introducing time-dependence into classic science explained those issues, and its consequent use led to the birth of a series of modern sciences, including relativistic and quantum physics. Classic computing is based on the paradigm proposed by von Neumann for vacuum tubes only, which seems to be completed in the same sense. Von Neumann warned, however, that implementing computers under more advanced technological conditions, using the paradigm without considering the transfer time (and especially attempting to imitate neural operation), would be unsound. However, classic computing science persists in neglecting the transfer time and is facing a few (but growing number of!) unexplained issues, and its development stalled in most of its fields. Introducing time-dependence into the classic computing science explains those issues and discovers the reasons for its experienced stalling. It can lead to a revolution in computing, resulting in a modern computing science, in the same way, as it resulted in modern science's birth.

Keywords: *temporal logic of computing, modern computing paradigm, temporal behavior in computing science, computing performance, stalling, efficiency of ANNs.*

GJCST-A Classification: *F.4.1*

WHYDOWENEEDTOINTRODUCETEMPORALBEHAVIORINBOTHMODERNSCIENCEANDMODERNCOMPUTINGWITHANOUTLOOKTORESEARCHINGMODERNEFFECTSMATERIALSANDTECHNOLOGIES

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Why do we need to Introduce Temporal Behavior in both Modern Science and Modern Computing, With an Outlook to Researching Modern Effects/Materials and Technologies

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Abstract- Classic science seemed to be completed more than a century ago, facing only a few (but growing number of!) unexplained issues. Introducing time-dependence into classic science explained those issues, and its consequent use led to the birth of a series of modern sciences, including relativistic and quantum physics. Classic computing is based on the paradigm proposed by von Neumann for vacuum tubes only, which seems to be completed in the same sense. Von Neumann warned, however, that implementing computers under more advanced technological conditions, using the paradigm without considering the transfer time (and especially attempting to imitate neural operation), would be unsound. However, classic computing science persists in neglecting the transfer time and is facing a few (but growing number of!) unexplained issues, and its development stalled in most of its fields. Introducing time-dependence into the classic computing science explains those issues and discovers the reasons for its experienced stalling. It can lead to a revolution in computing, resulting in a modern computing science, in the same way, as it resulted in modern science's birth.

Keywords: temporal logic of computing, modern computing paradigm, temporal behavior in computing science, computing performance, stalling, efficiency of ANNs.

I. Introduction

Computing science is on the border of mathematics and, through its physical implementation, science. From the beginning of computing, the computing paradigm itself, "*the implicit hardware/software contract* [3]", has defined how the mathematics-based theory and its science-based implementation must cooperate. The contract is based on the famous "First Draft" [22]. Von Neumann warned, however: "*6.3 At this point, the following observation is necessary. In the human nervous system, the conduction times along the lines (axons) can be longer than the synaptic delays, hence our above procedure of neglecting them aside of τ [the processing time] would be* ***unsound****. In the actually intended vacuum tube interpretation, however, this procedure is justified: τ is to be about a microsecond, an electromagnetic impulse travels in this time 300 meters, and as the lines are likely to be short compared to this, the conduction times may indeed be neglected. (****It would take an ultra-high frequency device*** – $\approx 10^{-8}$ ***seconds or less – to vitiate this argument.****)*" That is, according to its inventor, *the paradigm is justified only for the relationship between transfer time and processing time, represented by vacuum tubes*, and is surely unsound for workloads mimicking neural behavior. However, von Neumann did not suggest another procedure that we could follow when using a different technology.

The technological development of computing has changed the relationship between those timings drastically. Today, the data transfer time is much longer than the time needed to process it (and led to the symptom that moving data requires more energy [25] than manipulating it). Besides, the relative weight of data transfer time has grown tremendously, for many reasons. We cannot neglect it anymore; even it started to dominate computing. Firstly, miniaturizing the processors to sub-micron size while keeping the rest of the components (such as buses) above the centimeter scale. Secondly, the single-processor performance has stalled [31], mainly because of reaching the limits the laws of

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nature enable [21] (but, as we present, also because of tremendously extending its inherent idle waiting times). Thirdly, making truly parallel computers failed [3], and we can reach the needed high computing performance only through putting together an excessive number of segregated processors. This latter way replaced *parallel computing* with *parallelized sequential computing*, disregarding that the operating rules of the latter [26]**[36][33]** sharply differ from those experienced with segregated processors. Fourthly, the utilization mode (mainly multitasking) forced us to use an operating system (OS), which imitates a "new processor" for a new task, at serious time expenses [29][8]**[37]**. Finally, the idea of "real-time connected everything" introduced geographically large distances, with their corresponding several millisecond data transfer times. Despite all of this, the idea of non-temporal behavior was confirmed by accepting "weak scaling" [13], suggesting that *all housekeeping times, such as organizing the joint work of parallelized serial processors, sharing resources, using exceptions and OS services, delivering data between processing units and data storage units are negligible.*

Von Neumann was aware of the technological development and suggested to revise the validity of the paradigm when entering a new technology age. However, the theoretical basis for computing remained his original paradigm, and the solid mathematical background of computing science is still based on it; that is ***unsound*** under the present technological conditions.

The classic computing science kept the idea of "instant delivery"; although even within the core, wiring (and its related transfer time) has an increasing weight [21] in the timing budget. Moreover, computing systems "*have a clock signal which is distributed in a tree-like fashion into every tiny part of the chip... Approximately 30 % of the total consumption of a modern microprocessor is solely used for the clock signal distribution.*" [39] It seems to be the case that the (through their technical implementation: science-based) electronics components, of course, "know" their correct ("modern") temporal behavior. Their designers, however, attempt to keep the illusion of a time-independent operating regime. Or, maybe they have no formalism to handle temporal logic?

Mathematics considers only logical *dependencies* between its operands: it assumes that its operands are instantly available, and that the value of logical expressions it uses do not change if we evaluate at a different time or different place. The resemblance of mathematics and classic science is evident: both of them consider instant interaction. In other words, both classic science and classic computing assume infinite interaction speed between its objects. The approach is OK as long as pure mathematics is considered, but in computing, a physical implementation of mathematical expressions is used, and that implementation (of course) follows the laws of nature (NOT the laws of classic science). However, to discuss features of technological computing systems and to introduce into computing science their correct, science-based behavior is out of the scope of "computing science". Classic science enables accelerating a spaceship to a speed exceeding the speed of light, while modern science says it is impossible. The more than 100 years old 'modern science' did not yet touch 'computing science', and this hiatus led on one side to stalling of computing, from single-processor performance through supercomputers to Artificial Neural Network (ANN)s; on the other side, to wasting energy on heating and cooling, rather than computing.

In science, assuming that the speed of light is a limiting speed, enabled us to explain the mystic events, such as adding speeds was non-linear any more, and other experiences (and a different thinking about them!) revealed the non-continuous nature of energy. The method, transforming classic science into modern science, seems to be promising for transforming classic computing into modern computing.

II. Famous Issues with Computing

The vast computing systems can cope with their tasks with growing difficulty, enormously decreasing computing efficiency, and irrationally growing energy consumption; one can experience similar issues in the world of networked edge devices. Being not aware of that the collaboration between processors needs a different approach (upgraded paradigm), resulted in demonstrative failures already known (such as the supercomputers Gyoukou and Aurora'18, or the brain simulator SpiNNaker)[1] and many more may follow: such as Aurora'21 [28], the China's mystic supercomputers[2] and the EU planned supercomputers[3]. The new world champion (as of November 2020) *Fugaku* stalled at some 40% of its planned capacity [10].

General-purpose computing systems comprising "only" millions of processors already show the issues, and the brain-like systems want to comprise four orders of magnitude higher number of computing elements [17]. Moreover, when targeting neuromorphic features such as "deep learning training", the issues start to manifest at a few couples of dozens of processors [16]**[34]**. The scaling is nonlinear **[36]**, strongly depending on the workload type, and "*artificial intelligence, ... it's the most disruptive workload from an I/O pattern perspective*"[4] **[34][36]** one can run on conventional architectures.

"*Successfully addressing these challenges [of neuromorphic computing] will lead to a new class of computers and systems architectures*" [30]. However, as noticed by judges of the Gordon Bell Prize, *"surprisingly, [among the winners of the supercomputer competition] there have been no brain-inspired massively parallel specialized computers"* [4]. Despite the vast need and investments, the concentrated and coordinated efforts, just because of the critical bottleneck: ***the missing modern computing theory***.

III. Introducing Time to Computing

As suspected by many experts, the computing paradigm itself, "*the implicit hardware/software contract* [3]", is responsible for the experienced issues: "*No current programming model is able to cope with this development [of processors], though, as they essentially still follow the classical van Neumann model*" [27]. On one side, when thinking about "advances beyond 2020", the solution was expected from a "*more efficient implementation of the von Neumann architecture*" [20]. On another side, it was guessed that "*the von Neumann architecture is fundamentally inefficient and non-scalable* for representing massively interconnected neural networks" [23]. Even publications in the most prestigious journals [5][24] are missing the need to introduce temporal behavior.

[1] The explanations are quite different: Gyoukou was withdrawn after its first appearance; Aurora failed: retargeted and delayed; Despite the failure of SpiNNaker1, the SpiNNaker2 is also under construction [18]; "Chinese decision-makers decided to withhold the country's newest Shuguang supercomputers even though they operate more than 50 percent faster than the best current US machines".

[2] https://www.scmp.com/tech/policy/article/3015997/china-has-decided-not-fan-flames-super-computing-rivalry-amid-us

[3] https://ec.europa.eu/newsroom/dae/document.cfm? doc_id =60156

[4] https://www.nextplatform.com/2019/10/30/cray-revamps-clusterstor-for-the-exascale-era/

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a) The limiting speed in science

Classic science knows the temporal dependence of interactions (from our point of view: transferring information via physical interaction) only in the sense that if we move, for example, an electric charge, the *frequency* of the generated electromagnetic (EM) wave can be calculated. However, because of assuming instant interaction, the *speed* of the EM wave cannot: *the instant interaction is achievable only having infinitely large speed*. Due to this hiatus, *one of the vital features of computing (including neural) networks remained out of sight of the research*. This hiatus was resulting in an incomplete description of their behavior.

The fact that the speed of light is finite was known since Galilei. Moreover, Einstein discovered that interactions, such as forces between objects having electric charge or gravitational mass, have a finite interaction speed (in other words, their interaction is not instant, although very fast). In his (implicit[5]) interpretation, *there exists a universal limiting speed for interactions, that even the light (given that it is a propagating electromagnetic interaction) cannot exceed*. The scientific truth about the existence of a finite interaction speed, in general, was recently confirmed by providing experimental evidence for the existence of gravitational waves.[6] The experimental evidence also indirectly underpins that *the mathematical background of the Minkowski transform is well-established and correctly describes nature*, where the speed of interaction is limited. Modern treatments of special relativity base it on the single postulate of Minkowski spacetime [7].

b) The time in computing

In our electronic devices, the EM waves are propagating with a speed proportional to light's speed; that is, they have a *limiting speed*. In the first computer [15,12] (as well as in the present computers), the interaction speed was in the range of 10^8 m/s-range. The "processor size" was in the m-range, the timings (cycle length, access time, instruction's execution time) in the $msec$-range. Under those conditions, the data transfer time, also theoretically, could be safely neglected, as von Neumann emphasized it. For today, thanks to the technological development, the processor dwarfed million-fold, the timing got million-fold faster. The interaction speed, however, did not change. Since the first personal computers' appearance, the physical components' characteristic size, such as the length of buses connecting their components, did not change significantly (unlike the distance of computing gates, see Moore's observation).

Thanks to the decreasing density and the increasing frequency, *the speed of changing the electronic states in a computing system, more and more approached the limiting speed*. It was recognized that the system's clock signals must be delayed [39], that effort takes nearly half of the power consumption of the processor (and the same amount of energy is needed for cooling). Furthermore, only about 20% of the consumed (payload) power is used for computing [25]; the rest goes for transferring data from one place to another. Despite these shortcomings, it was not suspected that *the physical implementations of*

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[5] Einstein in his classic paper "On the electrodynamics of moving bodies" [11] speaks about that "light is always propagated in empty space with a definite velocity c," given that the light represents the propagation of the electromagnetic interaction. However, in the abstract of his paper, he mentions that he speaks about "the phenomena of electrodynamics as well as of mechanics", i.e., gravity. The formalism, however, was available for electrodynamics only; for gravity only a decade later.

[6] Both assuming the non-instant nature of those interactions, and demonstrating their existence, deserved Nobel price.

the electronic components have a temporal behavior [**35**]. However, it was the final reason for many experienced issues, from the payload performance limit of supercomputers [**33**] and brain simulation [**32**], to the weeks-long training time in deep learning [**34, 36**].

c) The limiting speed in biology

In contrast with technical computing, in biological computing systems, the "spatiotemporal" behavior of dynamically interacting neurons is explicitly investigated. Their interaction speed ("conduction velocity") depends both on their inherent parameters and actual conditions. The cm-range distances, the m/s-range interaction speed, and the $msec$-range timings (periodicity, spike length, etc.) prove that the biological networks' apt description is feasible only with temporal logic. In this context, both theoretically and in real-time[7] simulations: the temporal behavior is a vital feature of biological systems.

The "liquid state machine" model grasps the essential point of the biological neural networks: *their logical behavior cannot be adequately described without using both time and space coordinates*. The standard interpretation is used in former studies in describing neural behavior: the mathematical formalism used time (t) as an independent parameter that was not connected (through the interaction speed of the action under study) to the spatial coordinates. Thus, that model cannot provide a full-featured description of biological neural networks' behavor, furthermore it does not enable us to analyze their technical implementations' temporal behavior.

d) The common mathematics describing the limiting speed

The Minkowski-transform become famous for its role in accepting, quickly and widely, Einstein's special relativity theory. For our paper, we only assume that a limiting speed (in both electronic and biological systems) exists, and *transferring information in the system needs a limited time*. In biology, the limiting speed (the conduction velocity) is modulated, but our statement holds for any single action: *the spatial and temporal coordinates are connected through the corresponding limiting speed*. In our approach, *Minkowski provided a mathematical method to describe information transfer phenomena in a world where the interaction speed is limited*. For example, if we have our touching sense as the only source of information from the external world, we need to walk to the object, automatically limiting the information propagation speed (both touching and being touched) to our walking speed. This case is the same when transferring information in computing systems: space-time four-coordinates describe that world. The only new assumptions we make are that the events also have a processing time, such as an atomic transition, executing a machine instruction or issuing/receiving a neural spike[8], furthermore, that the limiting interaction speed is other than the speed of light.

We can proceed, following Minkowski, merely introducing a fourth coordinate, and through the assumed limiting speed (without making further assumptions about the value and nature of that speed), we can *transform the time of propagation of an event (the interaction, aka the physical transfer of the information) to a distance*, within which the interaction can have an effect in the considered time duration. *Notice the critical aspect, that space and time not only have equal rank, but they are connected through the interaction speed, and that all coordinates have the same dimension.*

[7] The real-time in our terminology means that all computing events happen on the biologically correct time scale, instead of that, on average, the computing time matches the biological time.

e) Details of the mathematical discussion

In computing, the distances get defined during the fabrication of components and assembling the system. In biological systems, nature defines the neuronal distances, and in 'wet' neuro-biology, signal timing rather than axon length is the right (measurable) parameter. To introduce *temporal logic* (meaning: the logical value of an expression depends on WHERE and WHEN is it evaluated) into computing, we need the reverse of the Minkowski transformation. We need to use a special four-vector, where *all coordinates are time values*: the first three are the corresponding local coordinates divided by the speed of interaction, having a time dimension; the fourth coordinate is the physical time itself. *The distances from the event's location are measured along with their access path; instead of calculating them from their corresponding spatial coordinates.*

That is, we introduce a *four-dimensional time-space* system. The resemblance with the Minkowski space is evident, and the name difference signals the different utilization methods. For a better visibility, the third spatial dimension is omitted in the figures. Figure 1 (essentially a light cone in 2D space plus a time dimension) shows *why time must be considered explicitly in all kinds of computing*. The figure shows that an event happens in our *time-space system* at point (0,0,0). Our observers are located on the 'x' axis; the vertical

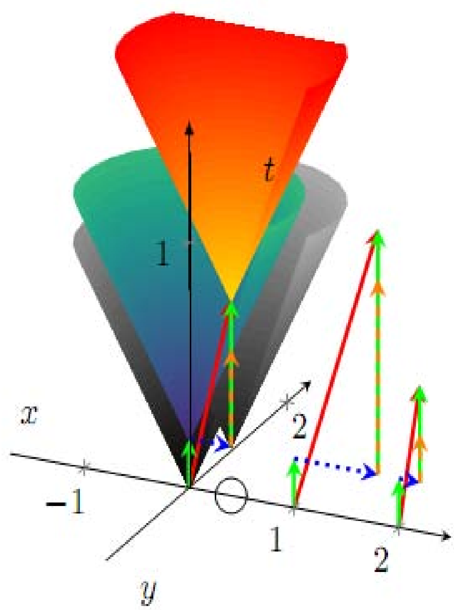


Fig.1 The Computing operation in *time-space* approach. The processing operators (depending on the granularity concerned) can be gates, processors, neurons, or networked computers. The "idle waiting time", rooting in the finite interaction speed and the physical distance of computing elements (see mixed-color vectors in figure), is one of the major sources of inefficiency of computing systems.

scale corresponds to the time. In the classic physical hypothetical experiment, a light is switched on in the origin. The observer switches his light on when he notices that the first light is switched on. The time when the observer notices the light is given as its distance from the origin divided by the speed of light. At any point in time on the vertical axis, a circle describes the propagation of light. In our

[8] Receiving a neural spike, however, is a little bit particular case: because of the integration, in some cases, the "processing time" can vary.

(pseudo) 3-dimensional system, the temporal behavior is described as a conical surface, known as the *future light cone*.

Both light sources have some 'processing time' that passes between noticing the light (receiving an instruction) and switching their light (performing an instruction). An instruction is received at the bottom of the green arrow. The light goes on at the head of the arrow (i.e., at the same location, but at a later time) when the 'processing time' T_p passed. Following that, light propagates in the two spatial dimensions as a circle around the axis 't'. Observers at a larger distance notice the light at a later time: a 'transmission time' T_t is needed. If the 'processing time' of the light source of our first event were zero; the light would propagate along the gray surface at the origo. However, because of the finite processing time of the source, the light propagates along the blueish cone surface, at the head of the green arrow.

A circle marks the position of our observer on the axis 'x'. With zero 'transmission time', a second gray conical surface (at the head of the horizontal blue dotted arrow) would describe his light. However, this second 'processing time' can only begin when our observer notices the light at his position: when the mixed-color vertical dashed arrow hits the blueish surface. At that point begins the 'processing time' of our second light source; the yellowish conical surface, beginning at the second vertical green arrow describes the second light propagation. The horizontal (blue dotted) arrow describes the physical distance of the observer (as a time coordinate), the vertical (mixed color dashed) arrow describes the time delay of the observer light. It comprises two components: the T_t transmission time (mixed color) to the observer and its T_p processing time (green). The light cone of the observer starts at $t = 2 * T_p + T_t$.

The red arrow represents the resulting *apparent processing time* T_A: the longer is the red vector, the slower is the system. As the vectors are on the same plane, $T_A = \sqrt{T_t^2 + (2 \cdot T_p + T_t)^2}$, that is $T_A = T_p \cdot \sqrt{R^2 + (2+R)^2}$. *The apparent operating time is a non-linear function of both of its component times* and *their ratio* R. If more computing elements are involved, T_t denotes the longest transmission time. (Similar statement is valid if the T_p times are different.) The effect is significant: if $R = 1$, the apparent execution time of performing the two computations is more than three times longer than T_p. Two more observers are located on the axis 'x', at the same position, to illustrate the influence of the transmission speed (and/or ratio R). For visibility, their timings are displayed at points '1' and '2', respectively. In their case, *the transmission speed differs by a factor of two* compared to that displayed at point '0'; in this way, three different $R = T_t/T_p$ ratios are used. Notice that at half transmission speed (the horizontal blue arrow is twice as long as that in the origin) the vector is considerably longer, while at double transmission speed, the decrease of the time is much less expressed[9].

f) The role of time in performance

In our particular coordinate system, formally (x,y,t) coordinates are used. That is, what happens in time in a component at position (x,y), is depicted along a line parallel with axis t, at (x,y). *The objects are annotated with their spatial position coordinates 'x' and 'y'. Those coordinates are time values: how much time the signal having the limiting speed needs to reach that point.* They may alternatively be positioned at some arbitrary position that corresponds to the same *time distance* from the point (0,0,0) (a cylindrical coordinate system

[9] This wants only to illustrate the effect of transmission speed on observations. This phenomenon is discussed in detail in **[33]**.

would be adequate but would make both visualization and calculations much harder to follow). *The interaction vectors are neither parallel with any of the axes nor are in a spatial plane: both their temporal and spatial coordinates change as the interaction propagates.* The arrows in the same horizontal plane represent the same time (no transmission). The horizontal blue arrows are just helper lines: the position (annotated by x,y, but denoting the time the signal from (0,0,0) needs to reach this position) is projected to the *time* axes x and y. The thin red arrow is the vectorial sum of the two projections, also in that plane.

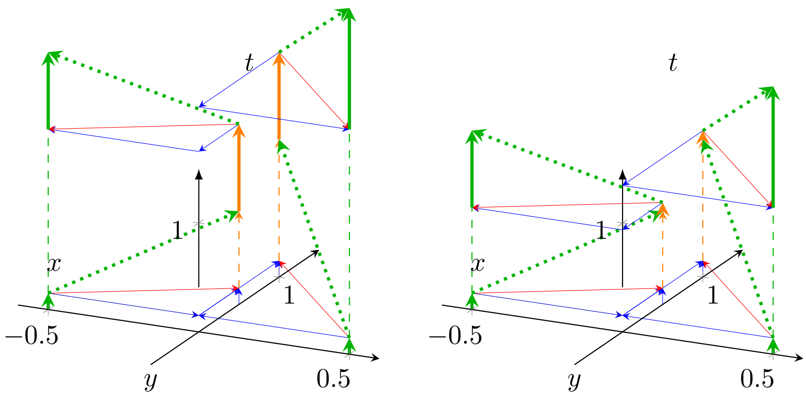


Fig. 2 The dependence of on-chip cache memory's operating speed at different physical cache operating times, in the same topology. The cores at (-0.5,0) and (0.5,0) positions access on-chip cache at (0,0.5) and (0,1), respectively. Vertical orange arrows represent physical cache operating time. Cache memories, from left to right, have physical access speed (on some arbitrary scale) 1 and 10, respectively. The Vertical arrows (from the bottom of the lower arrow to the top of the upper arrow) represent the apparent access time.

Given that the *apparent processing time* T_A defines the performance of the system, T_p and T_t must be concerted. Fig. 2 demonstrates why: two different topologies and two different physical cache operating speeds are used in the figure. The signal, requesting to access the cache, propagates along the dotted green vector (it changes both its time and position coordinates; recall that position coordinates are also mapped to time), the cache starts to operate only when the green dotted arrow hits its position. Till that time, the cache is idle waiting. After its operating time (the vertical orange arrow), the result is delivered back to the requesting core. This time can also be projected back to the "position axes", and their sum (thin red arrow) can be calculated. Similarly, the requesting core is also "idle waiting" until the requested content arrives.

The physical delivery of the fetched value begins at the bottom of the lower thick green arrows includes waiting (dashed thin green lines), and finishes at the head of the upper thick green vector; their distance defines the *apparent cache access time* that, of course, is inversely proportional with the *apparent cache access speed*. Notice that the *apparent processing time* is a monotonic function of the physical processing speed, but because of the included 'transmission times' due to the physical distance of the respective elements, their dependence is far from being linear. The *apparent cache speed* increases either if the cache is physically closer to the requesting core or if the cache access time is shorter (or both). The apparent processing time (represented by vertical green arrows) is only slightly affected by the cache memory's physical speed (represented by vertical orange arrows). See also section 5.5.

As the positioning of the cache and selecting its technology is a question of design, *the figure enables us to optimize timing versus expenses.* The figure also explains the rationale behind "in-memory" computing: most of the wasted "idle waiting" time can be eliminated. Repeated operations, of course, can change the idle to active ratio. However, one must consider the resources the signal delivery uses (they may use the same bus).

IV. The Price of Being Idle

The transmission time is an 'idle time' (the mixed-color arrow in Fig. 1) for the observer: it is ready to run, takes power, but does no useful work. Due to their finite physical size and limited interaction speed (both they are neglected in the classic paradigm), *the temporal operation of the computing systems results inherently in an idle time of their processing components.* As it sensitively depends on many factors and conditions, it can be a significant contributor to the processing time's non-payload portion. With other significant contributors, originating from their technical implementation [**37**], these "idle waiting" times sharply decrease the payload performance of the systems. In other words, the "idle waiting time" *leads to low computing efficiency and/or enormously large energy consumption.*

a) Gate-level processing

The temporal diagram of a 1-bit adder is shown in Fig. 3. The operations the gates perform are the same in both subfigures. The gates are aligned along axis X and the signals along axis y. The difference between the two cases is the position of the second XOR gate. The absolute distance from the origin and the signal sources are the same, but the other involved gates' distances are different. Notice that the signal c_o is produced in both cases at the same time. The signal sum, however, has entirely different timing, just because of the different wiring.

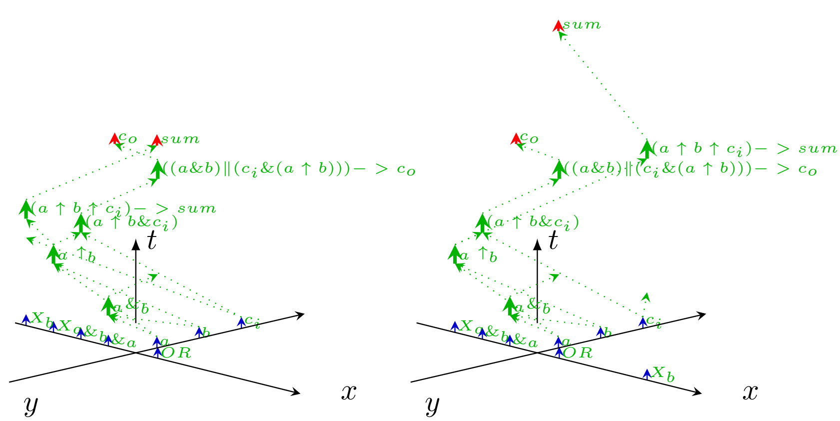


Fig. 3 The temporal dependence diagram of a 1-bit adder. The second XOR gate is at (-1,0) and (+1,0), respectively. Notice how changing the position of a gate affects signal timing. *The lack of vertical arrows* signals "idle waiting" time (undefined gate output)

The gates are ready to operate, and the signals are ready to be processed (at the head of the blue arrows). The logic gates have the same operating time (the length of the green vectors); their access time distance includes the needed multiplexing. The signal must reach their gate (dotted green arrows), that (after its operating time passes) produces the output signal which starts immediately towards the next gate. The vertical green arrows denote gate processing (their label shows the operation they perform, and one can project the arrow to axis x to find out the gate's ID). There are "pointless" arrows in the figure. For example, the signal $a\&b$ reaches the OR gate much earlier than the signal to its other input. Depending on the operands of OR, it may or may not result in the final sum. *The signals have their presumed values only after they received both of their inputs and processed them. Before that time, the value of the signal is undefined.*

Notice that considering the physical distance and the finite interaction speed drastically changes the picture we have (based on "classic computing"), that the operating time of an adder is simply the sum of its "gate times". For example, the first AND and XOR operations could work in parallel (at the same time), but the difference in their physical distance the signals must travel changes the times when they can operate with their signals.

The difference in timing roots not only in the different number of gates involved: the distance traversed by the signals can contribute equally, and even they can counterbalance the different number of the involved gates. As the c_o output is the input c_i for the next bit, it must be wired there. The total execution time of, say, a 64-bit adder shall be optimized at that level rather than at the bit level. Orchestrating the gates' temporal operation by considering both the complexity of their operation and the positions of signals and operators can significantly enhance their performance.

The goal of this section and Fig 3 is only to call attention to that *in addition to the viewpoint of mathematics (using standard gates and logic functions) and technology (which technology enables to produce shorter gate times and smaller expenses), also the temporal behavior must be considered when designing chips.* Even inside a simple adder circuit, one can change the performance significantly, only via changing the physical distance of the gates; in contrast with the "classic computing". *The total operating time of the adder is considerably longer than the sum of its gates' operating times.* The proper positioning of gates (and wiring them) is a point to be considered seriously, and maybe also the role of gates must be rethought.

Notice that this type of 'idle time' remains hidden for single-processor performance measurements. It was experienced, however, that general-purpose chips are very inefficient [14]: data signals must be delivered from one gate to another. Dividing larger designs into clock regions and distributing clock signal "in a tree-like fashion" [39], just to cover the temporal behavior of the components, introduces an artificial loss that should be avoided using "modern" (time-aware) design methods.

V. The Temporal Behavior of Selected Bottlenecks of Computing

The technical implementations of computing are usually designed assuming time-independence and significantly contribute to the experienced inefficiency of computing systems.

a) Connecting components

The elements of a computing system are prepared separately, and they are connected through a several cm-long buses. A sub-nanosecond processing time is associated with a nanosecond transmission time, clearly making the paradigm *unsound*. The "in memory" processing reduces this time and decreases the "idle waiting" time, increasing the apparent processing speed.

Fig. 4 discusses, in terms of "temporal logic", why *using high-speed buses for connecting modern computer components leads to very severe performance loss; furthermore, that it strongly distorts the true timing relations.* It is valid for any processing units, but it is especially disadvantageous when one attempts to imitate neuromorphic operation. The processing unit is called 'neuron' here, and a workload of type ANN is assumed; see also section 5.4.

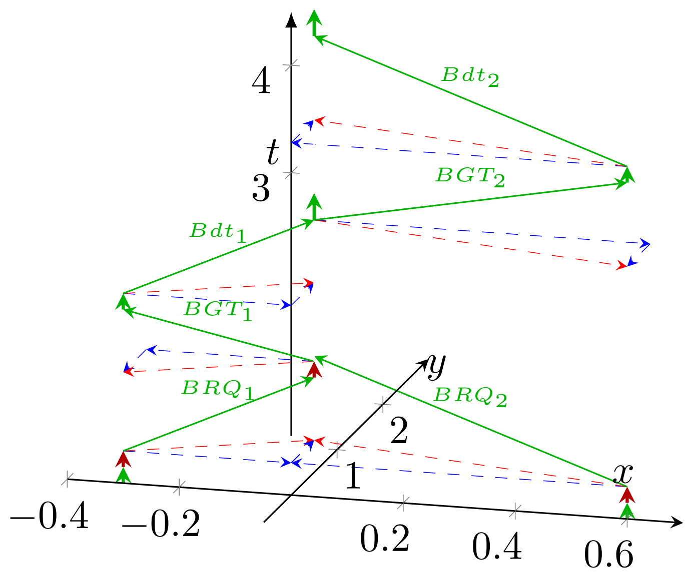


Fig. 4 The operation of the sequential bus in the time-space coordinate system. Near to axis t, *the lack of vertical arrows* signals "idle waiting" time

The two neurons of the hidden layer are positioned at (-0.3,0) and (0.6,0). The bus is at a position (0,0.5). The two neurons make their computation (green arrows at the position of neurons), then they want to tell their result to their peer neurons. Unlike in biology, first, they must have access to the shared bus (red arrows). The bus requests need time to reach the arbiter. The core at (-.3,0) is closer to the bus, so its request is granted. As soon as the grant signal reaches the requesting core, the bus operation is initiated, and the data starts to travel to the bus. As soon as it reaches the bus, the bus's high speed forwards it, and at that point, the bus request of the other core is granted. Finally, the computed result of the second neuron is bused.

At this point comes into the picture the role of the workload on the system: the two neurons in the hidden layer want to use the single shared bus, at the same time, for communication. As a consequence, *the apparent processing time is several times higher than the physical processing time. It increases linearly with the number of neurons in the hidden layer* (and maybe also with the total number of neurons in the system, if a single high-speed bus is used).

In vast systems, especially when attempting to mimic neuromorphic workload, the bus's speed is getting marginal. Notice that the times shown in the figure are not proportional: the (temporal) distance between cores are in the several picoseconds range, while the bus (and the arbiter) is at a distance well above nanoseconds, so *the actual temporal behavior (and the idle time stemming from it) is much worse than the figure suggests.* This effect is why *"The idea of using the popular shared bus to implement the communication medium is no longer acceptable, mainly due to its high contention."* [19]. The figure suggests using another design principle instead of exclusively using the bus directly from the computing component's position.

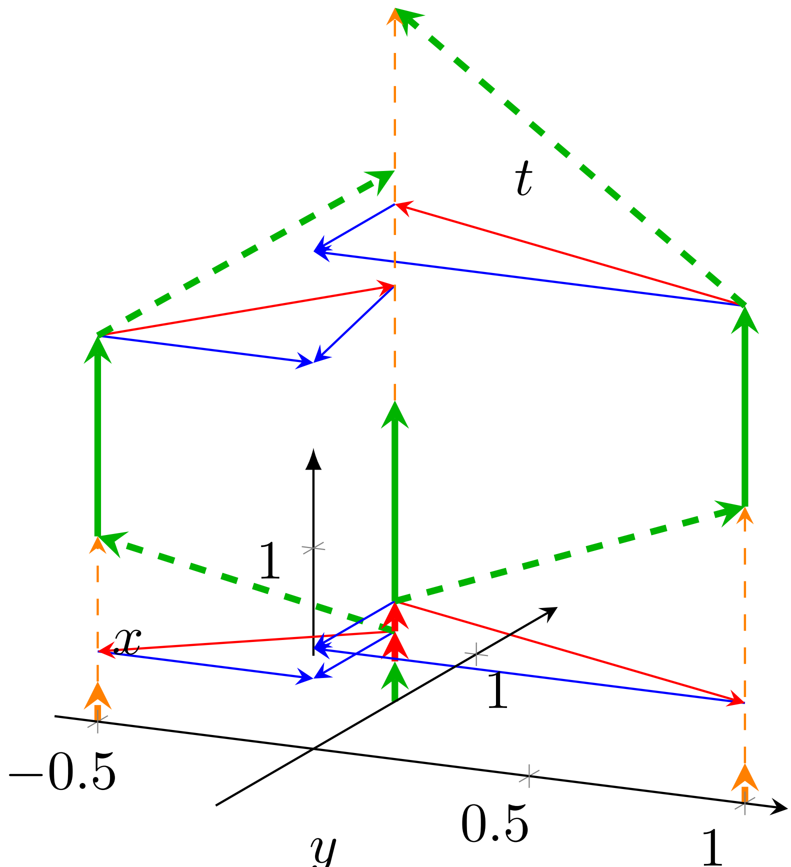
b) Synchronous and asynchronous operation

The case depicted in Fig.1 is an asynchronous operation: when the light cone arrives at the observer, the second processing can start. If we have additional observers, their transmission times may be different. Furthermore, we have no way to synchronize their operation. If we have another observer at the point mirrored to the origin, the light cone arrives at it simultaneously. However, to synchronize the two observers' operation, we would need a 2-fold longer extra synchronization time. Instead, we issue another light cone (the central clock) at the origin (in the case of that light cone, the processing time is zero, just a rising edge), and the observers are instructed to start their processing when this synchronizing light, rather than the event light, reaches their observation point. If the synchronization period is large enough, all observers will notice the event light: they will be within the synchronization light cone. After noticing the synchronization light, they can all start their processing at that time, which equals to the sum of the two processing times plus the synchronization time. *The idle time for all observers increases.* Given that the internal wiring can be very different, we must choose the clock period according to the "worst-case". All observers must wait for the slowest one. The more observers, the more waiting. This effect is considerable even inside the chip (at $\leq cm$ distances); in supercomputers, the distance is about 100 m.

A careful analysis **[32]** discovered that using synchronous computing (using clock signals) has a significant effect on the performance of large-scale systems mimicking neuromorphic operation. The performance analysis [2] of large-scale brain simulation facilities demonstrated another exciting parallel between modern science and large-scale computing. The commonly used 1 ms integration time limited both the many-thread software (SW) simulator, running on general-purpose supercomputers, and the purpose-build hardware (HW) brain simulator to the same performance. Similar shall be the case very soon in connection with building the targeted large-scale neuromorphic systems, despite the initial success of specialized neural chips (such as [23, 9]). Although at a higher value (about two orders of magnitude higher than the one in [2]), systems built from such chips also shall stall because of the "quantal nature of time" **[38]**, although using asynchronous operating mode can rearrange the scene.

c) Parallelized sequential computing

A major bottleneck in distributed computing is rooting also in "idle waiting", as was correctly identified decades ago [26]. One of the cores (in Fig. 5, the one



Operating diagram of parallelized sequential computing systems. One of the cores,

Fig.5 The Operating diagram of parallelized sequential computing systems. One of the cores, at position (0,0.5,0), orchestrates parallelization. Two more cores are participating in the job, at (-0.5,0,0) and (1,0,0). Notice that the larger physical distance leads to considerable delay in delivering the result back to the coordinator core. Green arrows denote payload, dashed orange arrows non-payload processing time.

at position (0,0.5,0)) starts with some sequential-only processing. In the next step, it shares the job with its fellow cores, cycling through their addresses. The core at (-0.5,0,0) is the first one. Notice that even in the timeless paradigm, the first core must 'idle wait' the sequential-only processing, plus the end of the first cycle. Given that the signal must propagate to it from the originating core, it can begin its part of computation only at the beginning of the green arrow. Similarly, the core at (1,0,0) is started in the second round. Notice that its idle waiting time is longer than that of the other core because of the looping in the initiator core, and similarly, its transmission time is also longer.

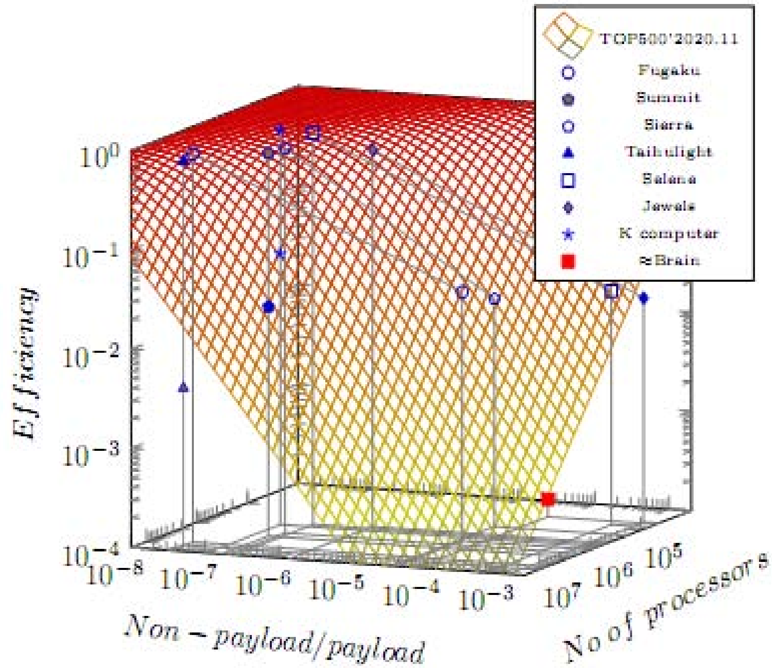


Fig. 6 The 2-parameter efficiency surface (in the function of parallelization efficiency measured by benchmark HPL and number of processing elements) as concluded from Amdahl's Law. Some sample efficiency values for some selected supercomputers are shown, measured with benchmarks HPL and HPCG, respectively. Also, the estimated efficacy of brain simulation using conventional computing is shown.

After sharing the job, all cores start to make their part of the computation. We assume that all cores need the same time to perform their part, and after that, they return the result to the organizer core. The orchestrator core must wait for the slowest fellow core; the processing time of the parallelized system is defined by the most considerable *apparent processing time*[10]. As shown in the figure, the looping (non-payload) contribution is increasing by adding more cores to the loop. Moreover, the transmission delay is increasing with the physical size of the supercomputer.

The parallelized sequential computing introduces a rule of 'adding performance' values in modern computing, which is quite similar to the rule of 'adding speed' values in modern physics **[38]**, see Fig. 7. The effect on the

[10] Notice that looping delay can be combined with propagation delay: their rational pairing enabled in the case of Sierra a 10+ % increase in its *payload performance* with 0 % increase in the nominal performance. Also, as the examples of recent world champions demonstrate, using assisting cores for both organizing the cooperation and performing other non-payload job, significantly increases their efficiency.

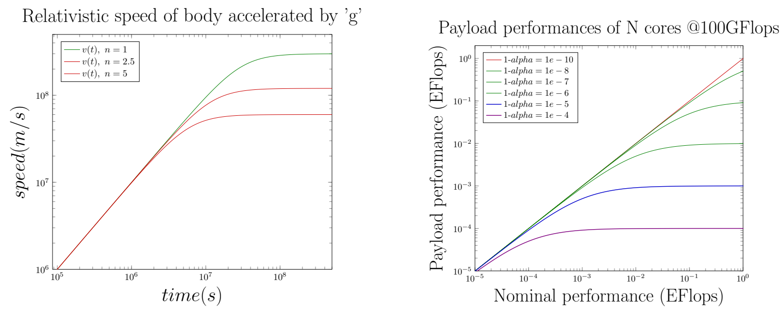


Fig. 7 The limiting effect is considered in "modern" theories. On the left side, the speed limit, as explained by the relativity theory, is illustrated. The refractory index of the medium defines the value of the speed limit. On the right side, the payload performance limit of parallelized sequential computing systems, as explained by the "modern paradigm", is illustrated. The ratio of non-payload to payload processing defines the value of payload performance.

efficiency of supercomputers is depicted in Fig. 6. This loss is natural that can be mitigated but cannot be eliminated.

Figure 6 also depicts how computing efficiencies of recent supercomputers depend (see its discussion in **[33]**) on the number of single-threaded processors in the system and parameter $(1-\alpha)$, describing the non-payload portion defined by the corresponding benchmark task. It is known since decades that "*this decay in performance is not a fault of the architecture, but is dictated by the limited parallelism*" [26]; in excessive systems of modern HW, *is also dictated by laws of nature* **[38]**.

d) Neuromorphic computing

Biology strictly considers both the physical distance and its components' operating speed: slight changes in values in their timing result in severe dysfunctionality. Biology uses a more complex computing system: not only that T_p and T_t times are in the same order of magnitude (i.e., their timely behavior must be considered), but also the conduction velocity (the interaction speed) is changed significantly, case by case (if needed, by a factor about one hundred!), to deliver the needed control signals to their place **[37]**. However, using the proposed *time-space system*, we can correctly describe the neuronal operation (that would be unsound, using the classic paradigm), too. However, we must consider that the interaction speed is different for the different components/events in their case.

In sections 5.1 and 5.3 was discussed the timely behavior of the serial bus (shared medium) and the distributed parallelized processing, respectively. The classic ANNs combine their disadvantages into one single inefficient system: *the signal transition time between neurons can be orders of magnitude higher than their processing time*. Given that, as discussed in section 4.1, *in a technological implementation of the neuronal operation, in most portion of the total time, the value of the output signal of neurons differs from the expected one*. These facts, combined, mean that when "training" ANNs, fellow neurons receive that (maybe wrong) output signal in most of their learning period, and correspondingly, they also provide (maybe) false input for the linked neurons. *Given that neurons do not know which is the "right" signal, upon receiving a new input; they adjust their synaptic weights to the wrong signal. The larger the system, the worse the effect; the result is weeks-long training, even for (compared to the functionality of the brain) straightforward tasks*. The effect of undefined output is, of course, known in engineering: for example, in processors, adders comprising several one-bit adders do not provide their final output until a fixed time (supposing that until that time signals in its components are relaxed).

The analysis of temporal behavior of ANNs underlines that, in general, "*artificial intelligence, ... it's the most disruptive workload from an I/O pattern perspective*"[11]. In practice, it means that imitating neuromorphic computing on conventional architectures can be performed only with very low computing efficiency [**32, 36**].

e) New materials and/or physical effects

Ongoing research may result in new physical effects and/or technologies and/or materials. The general temporal behavior of matter, however, limits their usability. Fig. 2 depicts the temporal behavior of a cache operation. Using a much quicker computing element in place of a the slower component has only a marginal effect if the transmission time (i.e., the physical size) limits the apparent speed of operation. Similar holds if one replaces the components with others (such as much quicker processing or storage element). *Mimicking the biology is also useful here: the time window where the decision is made*[12] *is of the same size, independently from both the path traversed by the signal (the axon length) and the signal's speed (conduction velocity). Furthermore, it is in the order of the 'processing time' of the neurons.*[13]

To fabricate smaller components without decreasing the processing time proportionally; and similarly, replacing a processing element with a very much quicker one (such as proposed in [6][1], and *may be proposed using any future new physical effect and/or material*) is not reasonable, and it has only a marginal effect, if the physical distance of the computing elements cannot be reduced proportionally at the same time. The speed of light is insurmountable and also limits the performance of future computing.

VI. Conclusion

This paper introduces the concept of timely behavior into computing (a temporal logic), while the model preserves the solid computing science base. The introduced formalism enables us to calculate the effects of temporal behavior, rooting in science, of our computing systems. All fields of computing benefit from introducing temporal behavior for computing components, from explaining the need of "in-memory computing" to reasoning the low efficiency of the Graphic Processing Unit (GPU)s in general-purpose applications and comprehending the experienced weeks-long training times of ANNs; as well as researching more new physical effects/ technologies/ materials. *Neglecting temporal behavior led already to waste vast amounts of energy and introduced performance limits for critical computing systems. Besides, it limits the utility of any future method, material, or technology, if they are designed/developed/used in the spirit of the old (timeless) paradigm.*

References Références Referencias

1. Building brain-inspired computing. Nature Communications **10**(12), 4838 (2019). URL https://doi.org/10.1038/s41467-019-12521-x
2. van Albada, S.J., Rowley, A.G., Senk, J., Hopkins, M., Schmidt, M., Stokes, A.B., Lester, D.R., Diesmann, M., Furber, S.B.: Performance Comparison of the Digital Neuromorphic Hardware SpiNNaker and the Neural Network Simulation Software NEST for a Full-Scale Cortical Microcircuit Model. Frontiers in Neuroscience **12**, 291 (2018)

[11] https://www.nextplatform.com/2019/10/30/cray-revamps-clusterstor-for-the-exascale-era/

[12] In computing: WHEN and WHERE the logical function is evaluated

[13] The biology can change the conduction velocity, which needs energy, so finding an optimum is not as simple.

3. Asanovic, K., Bodik, R., Demmel, J., Keaveny, T., Keutzer, K., Kubiatowicz, J., Morgan, N., Patterson, D., Sen, K., Wawrzynek, J., Wessel, D., Yelick, K.: A View of the Parallel Computing Landscape. Comm. ACM **52**(10), 56–67 (2009)
4. Bell, G., Bailey, D.H., Dongarra, J., Karp, A.H., Walsh, K.: A look back on 30 years of the Gordon Bell Prize. The International Journal of High Performance Computing Applications **31**(6), 469–484 (2017). URL https://doi.org/10.1177/1094342017738610
5. Bourzac, K.: Streching supercomputers to the limit. Nature **551**, 554–556 (2017)
6. Chicca, E., Indiveri, G.: A recipe for creating ideal hybrid memristive-CMOS neuromorphic processing systems. Applied Physics Letters **116**(12), 120501 (2020). DOI 10.1063/1.5142089. URL https://doi.org/10.1063/1.5142089
7. Das, A.: The special theory of relativity: a mathematical exposition, 1 edn. Springer (1993)
8. David, F.M., Carlyle, J.C., Campbell, R.H.: Context Switch Overheads for Linux on ARM Platforms. In: Proceedings of the 2007 Workshop on Experimental Computer Science, ExpCS '07. ACM, New York, NY, USA (2007). DOI 10.1145/1281700.1281703. URL http://doi.acm.org/10.1145/1281700.1281703
9. Davies, et al, M.: Loihi: A Neuromorphic Manycore Processor with On-Chip Learning. IEEE Micro **38**, 82–99 (2018)
10. Dongarra, J.: Report on the Fujitsu Fugaku System. Tech. Rep. Tech Report ICL-UT-20-06, University of Tennessee Department of Electrical Engineering and Computer Science (2016). URL http://bit.ly/fugaku-report
11. Einstein, A.: On the Electrodynamics of Moving Bodies. Annalen der Physik (in German) **10**(17), 891–921 (1905). DOI 10.1002/andp.19053221004
12. Godfrey, M.D., Hendry, D.F.: The Computer as von Neumann Planned It. IEEE Annals of the History of Computing **15**(1), 11–21 (1993)
13. Gustafson, J.L.: Reevaluating Amdahl's Law. Commun. ACM **31**(5), 532–533 (1988). DOI 10.1145/42411.42415

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Multi-Task Learning by Multi-Wave Optical Diffractive Network

By Jing Su, Yafei Yuan, Chunmin Liu & Jing Li
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Abstract- Recently, there has been tremendous researches in Optical neural networks that could complete comparatively complex computation by optical characteristic with much more fewer dissipation than electrical networks. Existed neural networks based on the optical circuit are structured with an optical grating platform with different diffractive phase at different diffractive points. In this study, it proposed a multi-wave deep diffractive network with approximately 106 synapses, and it is easy to make hardware implementation of neuromorphic networks. In the optical architecture, it can utilize optical diffractive characteristic and different wavelengths to perform different tasks. Different wavelengths and different tasks inputs are independent of each other. Moreover, we can utilize the characteristic of them to inference several tasks, simultaneously. The results of experiments were demonstrated that the network could get a comparable performance to single-wavelength single-task. Compared to the multi-network, single network can save the cost of fabrication with lithography. We train the network on MNIST and MNIST-FASHION which are two different datasets to perform classification of 32*32 inputs with 10 classes. Our method achieves competitive results across both of them. In particular, on the complex task MNIST-FASION, our framework obtains an excellent accuracy improvement with 3.2%. On the meanwhile, MNSIT also have the improvement with 1.15%.

GJCST-A Classification: C.2.1

MULTITASKLEARNINGBYMULTIWAVEOPTICALDIFFRACTIVENETWORK

Multi-Task Learning by Multi-Wave Optical Diffractive Network

Jing Su [α], Yafei Yuan [σ], Chunmin Liu [ρ] & Jing Li [Ѡ]

Abstract- Recently, there has been tremendous researches in Optical neural networks that could complete comparatively complex computation by optical characteristic with much more fewer dissipation than electrical networks. Existed neural networks based on the optical circuit are structured with an optical grating platform with different diffractive phase at different diffractive points. In this study, it proposed a multi-wave deep diffractive network with approximately 10^6 synapses, and it is easy to make hardware implementation of neuromorphic networks. In the optical architecture, it can utilize optical diffractive characteristic and different wavelengths to perform different tasks. Different wavelengths and different tasks inputs are independent of each other. Moreover, we can utilize the characteristic of them to inference several tasks, simultaneously. The results of experiments were demonstrated that the network could get a comparable performance to single-wavelength single-task. Compared to the multi-network, single network can save the cost of fabrication with lithography. We train the network on MNIST and MNIST-FASHION which are two different datasets to perform classification of 32*32 inputs with 10 classes. Our method achieves competitive results across both of them. In particular, on the complex task MNIST-FASION, our framework obtains an excellent accuracy improvement with 3.2%. On the meanwhile, MNSIT also have the improvement with 1.15%.

I. Introduction

Store and retrieve data units based on the Von-Neumann architecture are far more time-consuming and power-hungry than optical device [1-4]. Different from modern computers, cis integrated of data computation, storage and fetch, which more effective, less power, large storage capacity and higher integration level [5-7]. Besides, Artificial neural network is [8] similar to the way in which human and animal store and process data is successful in a wide range of tasks such as image analysis [9], speech recognition [10] and language translation [11]. Artificial neural network can get comparable or even superior performance than the human with the increasing data volume, problem complexity and structure depth. Most of tasks cannot be migrated well in smart portable devices for its complexity and power. The less-power, more-efficiency and faster speed is becoming more and more critical for deep learning implemented on embedded device.

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The neuromorphic computing seeks a brain-like processing, which overcome the limitation from conventional computers. IBM [12] built a 5.4-billion transistor chip with 4096 neurosynaptic cores called True North - a fully functional digital chip. To provide the extreme complexity of the human cerebral cortex, M Prezioso [13] et al combined complementary metal oxide-semiconductors (CMOS) and two-terminal resistive device with electric circuits. Spin-transfer torque magnetic memory [14] (STTMRAM) with non-volatility, high-speed and high endurance, is suitable as a stochastic memristive device, considering the functional implication of synaptic neuronal plasticity. Alexander N. Tait [15] inspired by spiking neural networks integrated laser devices to explore highly interactive information at speeds with optical-electronic systems. This approach promises to incorporate photonic spike processing in the training system. Besides, Carlos Rios dramatically improve storage capacity to implement all-photic nonvolatile [16] multi-level where memory electric-photic interconnect technologies bring not only opportunities but also challenges to the unconventional circuits and systems. To overcome the wastage of optical-electric conversions coupling, all photic device can be performed with fast computational speed and lower power. On-chip nonvolatile photic [17] device would dramatically improve performance in existing brain-like neural networks [18] to eliminate electronic latency and reduce electronic consuming. The on-chip optical architecture is designed for network protocol computational element and waveguide medium to communicate among high-performance spiking neurons.

The architecture of fully-optical network with Mach-Zehuder interferometer [19] promises the reduction of data-movement energy cost. All-optical diffractive deep neural network architecture (D2NN) [20] utilize passive component and optical diffraction. D2NN can be easily scaled up and fabricated by 3D lithography [21] in a power-efficient manner.

In general, optical networks have more trainable parameters with complex-value modulation which provide phase and amplitude of each neuron rather than only amplitude in electric networks. Unfortunately, optical device to forming neural network has some problems. Firstly, all-optical neural network is designed for a single task, but multi-tasks [22] are significant and important. Secondly, learning rates for different tasks are

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important to the accuracy. It is non-trivial to balance the tasks and learning rates.

In this paper, to address above two issues, we make most of the optical characteristics to express different tasks with different wavelengths. The one wavelength to use as baseband, the other is used as a carrier frequency. Therefore, the base band wave can be set to a large learning rate and vice versa. Extensive experiments based on MNIST and MNIST-Fasion [23] are conducted to investigate the efficacy and properties of the proposed multi-wavelength diffractive network (MWDN). In both two tasks, The MWDN significantly performs the baselines even better in the same network.

II. Multi-Wavelength Diffractive Network

Spatial domain implies per-wave in-plane propagation reasoning about diffractive in the particular phase and frequency which can analyze and integrate different direction waves. It operates in the frequency domain. The wave distribution of the observation and aperture plane can be viewed as the linear combination with a great many monochromatic plane wave of different direction propagation. The amplitude and phase of each plane wave lies on the angular spectrum. The angular spectrum can be acquired by FFT analysis [24] process. The plane wave propagation is a complex task that take into consider many affecting factors, such as direct, phase and amplitude.

As shown in Fig. 1, we adjust optical grating parameters (height and the complex index of refraction), the height is altered by 3D printed, and the complex index of refraction is altered by laser light with different power. Different power can alter different refraction of phase change materials. We input images in MNIST and MNIST-FASHION simultaneously, the input optical wavelength of MNIST and MNIST-FASION task is $\lambda 1$ and $\lambda 2$, respectively. The diffractive network with the different task has the same optical parameters. The bottom of the figure is the optical carrier. Fig. 2 shows the framework of diffractive network and different color denotes different index of refractive.

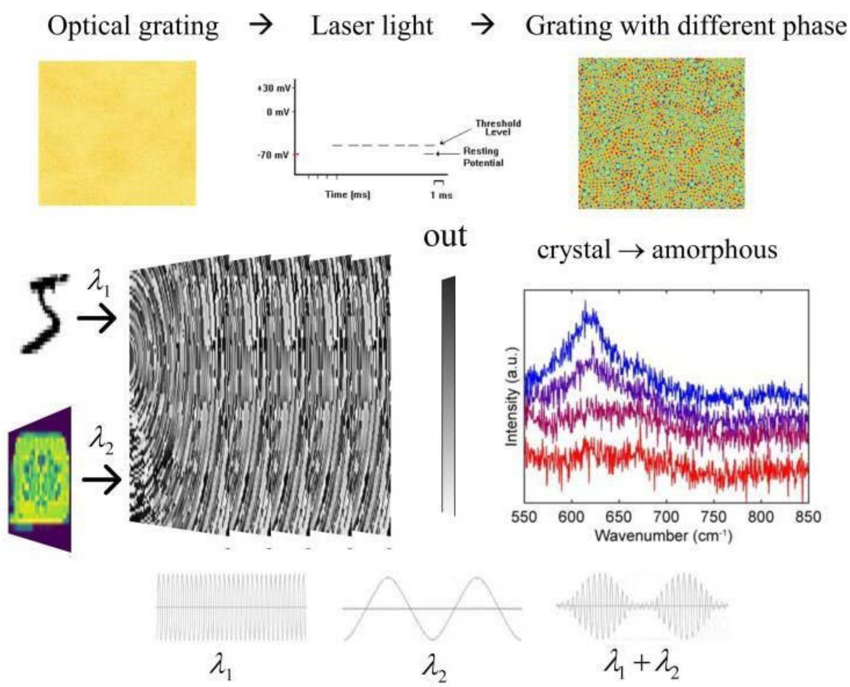

Fig. 1: The architecture of Multi-wavelength diffractive network

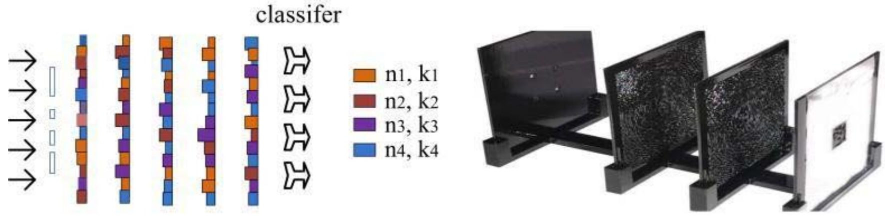

Fig. 2: The framework of Multi-wavelength diffractive network

Firstly, we convert image information to the phase and amplitude of optical information as the input of systems. Then, the optical grating is manufactured by 3D-printing device with different height. In the following sections, we discuss that MWDN tackles the tasks predominately using the angular spectrum. MWDN by the 3D-printing would influence the amplitude and phase of the wave to 0~1and 0~2π, for two tasks in the same network. For each layer of MWDN, we set the neuron size range 200μm to 700μm, which is an effect tunable.

Following the Fresnel diffraction equation, we can consider the optical signal from the spatial domain to the frequency domain. The angular spectrum method of plane wave explains how wave propagate. It is the primary method of analyzing diffraction in the frequency domain. Based on the angular spectrum, the free space transfer function is to control free propagation. The wave plane can transfer angular spectrum by FFT process, where diffractive data processing is more evident as follows:

$$A_0(f_x, f_y) = FFT(U_0(x, y)) = \sum_{x=0}^{N-1}\sum_{y=0}^{M-1} U_0(x, y) e^{-j2\pi(\frac{f_x x}{N}+\frac{f_y y}{M})}$$

$$A(f_x, f_y) = A_0(f_x, f_y)\cdot H(f_x, f_y)$$

$$U(x, y) = IFFT(A(f_x, f_y))$$

$$H(f_x, f_y) = \exp(jkz)\exp(j\pi\lambda z(f_x + f_y)^2)$$

Where, f_x, f_y are space frequency correspond to x, y location ($f_x = 1/(x-x_0)$), x-x_0 is gaps in the optical map, N and M is the number of grooves on optical grating in height and width direction, $U_0(x, y)$ is the original field distribution, $U(x, y)$ is the field distribution after free space transfer, $H(f_x, f_y)$ is transfer function, $A_0(f_x, f_y)$ is the original angular spectrum, $A(f_x, f_y)$ is the angular spectrum after free space transfer. The results of the inverse Fourier transform to transfer function, are the impulse response function. The equation can view as the Fourier transform.

$$h(x-x_0, y-y_0) = F^{-1}(H(f_x, f_y))$$
$$= \frac{1}{j\lambda z}\exp(jkz)\exp(j\frac{k}{2z}((x-x_0)^2 + (y-y_0)^2))$$

The output wave plane distribution propagates through 3D material and the field distribution is changed by the refractive index.

$$O(x, y) = U(x, y)\cdot(1-\alpha\cdot\Delta d)\cdot\exp(j\phi)$$

$$\phi = \frac{2\pi\Delta n_1\Delta d}{\lambda}, \Delta n_1 = n - n_0, \alpha = \frac{4\pi k}{\lambda}$$

Where α is extinction efficiency, n is the refractive index real part of 3D material, n_0 is the refractive index real part of the vacuum, k is the refractive index imagery part, λ is the wavelength, Δd is the height of material map, ϕ is the phase difference. If we choose transparent material ($k\to 0$) ignoring the optical losses, the transmission coefficient of a neuron is composed of only phase term; if we select non-transparent material, the transmission coefficient of a neuron is composed of amplitude and phase in MWDN architecture.

According to the size of input data, an effective and flexible linear interpolation algorithm is to fit the diffractive input layer. The interconnection rate between adjacent layers relates to the distance and diffraction angle, which approach the critical value (1.0).

Furthermore, the number of the network layers and the axial distance is also a tunable. The output layer can part into ten regions corresponding to ten classes, where the summation of light intensity can be detected in the wave plane region. Mean square error (MSE) uses to train MWDN parameters compared to the target. We aim to minimize a loss function, which increases target region wave intensity and decrease other regions. The training batch size set to be 10 for the classifier.

III. The Backward of Multi-Wavelength Diffractive Network

To train MWDN, we use the back-propagation algorithm with a dam optimization method.

We focus on the intensity of wave and define loss function with MSE between output and target.

$$E(\Delta d)=\frac{1}{K}\sum_{k=1}^{K}(o_k-t_k)^2$$

where K is the number of training data, o_k is the output of the MWDN, and t_k is the label of the corresponding input. The optimization problem can be written follows:

$$\min_{\Delta d_i^l} E(\Delta d_i^l)$$

where l is the layer, i is the l_{th} layer location. The gradient of loss to all parameters can be calculated, which is used to update MWDN architecture parameters during the training process. Each batch of the training data is fed into MWDN, where each layer gradient can be calculated to update.

IV. The Backward of Multi-Wavelength Diffractive Network

The optical diffractive network and deep neural network are markedly different. The function of the optical diffractive network is determined by wavelength and the parameters of the optical grating (height and complex refractive index). Multi-wavelength diffractive network has a broad range of requirements that differ from the conventional network.

Different wavelength has different effectiveness. We set different wavelength for different tasks. Meanwhile, the network needs to ensure that different wavelengths do not affect each other. By setting one to baseband and the other to the carrier, the diffractive network is used to adjust optical plane wave independently. The algorithm can be considered as an efficient carrier algorithm. The ratio of baseband and carrier wavelengths is 1:30. The short wavelength is little influence to long wavelength and vice versa. If the phase difference of long wavelength is ϕ_1 and the phase difference of short wavelength is ϕ_2, the corresponding relationship as follows:

$$\phi_1\lambda_1=\phi_2\lambda_2,\quad \lambda_1/\lambda_2=1:30$$

So, the equation can be as follows:

$$\phi_2/\phi_1=1:30,\qquad \phi_2\ll\Phi_1$$

$$\phi_1=2\pi n+\phi_1',n=0,1,2\ldots\ldots$$

$$\phi_2=\pi n/15+\frac{\phi_1'}{30},\phi_1'=0\sim 2\pi$$

The second terms of ϕ_2 is relative to the first term can be ignore, the equation can be shown as follows:

$$\phi_2\approx \pi n/15$$

The multi-wavelength diffractive network can be effective, and more powerful than deep neural network. Phase difference ϕ_i (i=1, 2) can be obtained easily by adjusting the height on the diffractive network. Due to $\phi_2 \ll \phi_1$, then we adjust Δd for minor learning rate for ϕ_2, as well as for large learning rate for ϕ_1, without one impacting the other.

$$\Delta d\approx \phi\lambda/2\pi\Delta n$$

V. Experiment

In this work, we apply the proposed MWDN to implement on two different dataset MNIST and MNIST-Fashion.

a) Model setup

By comparing to the state-of-the-art methods with accuracy and speed of, MNIST and MNIST-FASION in this method achieve better performance. The size of the network is set to 200×200, 500×500 and 1500×1500, each having a trainable height of the map. The optical network possesses two types, one for phase modulation, and the other for complex-modulation. The MNIST and MNIST-FASION tasks with different optical wavelengths, the input is altered by optical grating mask.

Using the backward propagation, the model is trained with two task datasets alternately, validated its effectiveness. We train the network with different learning rate for different tasks, which overcome the drawbacks of local optimum to solve. As well as, all the parameters of the network are adjusted by the gradient descent algorithm to minimize the error.

b) Dataset

We evaluate the approach on two datasets and input information for neurons in the form of phase fed into the network. The two datasets have different data distribution, which is difficult to classify in the same network. The conventional networks require the input information to be independent and identical distribution. The task is to handle two different distribution data in a same network.

c) Experimental analysis

For better performance, we set a different learning rate and different signal frequency to two datasets. The maximum half-cone diffraction angle is formulated as follow:

$$\varphi_{\max} = \sin^{-1}(\lambda / 2d_f)$$

The light wavelength is 0.4THz, 14.4THz for MNIST and MNIST fashion. The neuron size is set to be 200μm. The height of the map and axial distance between two successive layers are trainable. As comparing the performance of MWDN and DN methods with single task, the results was shown in Table 1. It is clearly that the performance of MWDN would improve the accuracy of 1.15% and 3.2%, independently. To evaluate the multi-wavelength for multi-task, so we compare the multi-task to a single task in Table 2. The multi-task diffractive network enables consistent performance with a single task. The result can perform well in the same parameters. The experiment set of setting 1 is the same wavelength for comparison. Setting 2 is performed by a different wavelength. The DN-FASION and DN-MNIST are evaluated by independent diffractive network.

Table 1: The performance of MWDN and DN methods

Method	MNIST	λ (THZ)	MNIST-Fasion	λ (THZ)
MWDN(PCM)	92.85%	0.4	84.33%	14.4
DN-MNIST	91.75%	0.4	81.13%	0.4

Table 2: The performance of MWDN and DN methods with multi-task

Method	MNIST	MNIST-Fasion	λ1 (THZ)	λ2(THZ)
Setting 1	23.45%	12.12%	0.4	0.4
Setting 2	90.45%	76.67%	14.4	0.144
DN-Fasion	/	78.70%	14.4	/
DN-MNIST	91.75%	/	/	14.4

d) Convergence analysis

Fig3 demonstrate two classifiers for two datasets, where each dataset has ten target class. One classifier is set to classify in the same region and another is set to a different region. The different frequency setting to different datasets is effective and different regions in the MWDN has high accuracy.

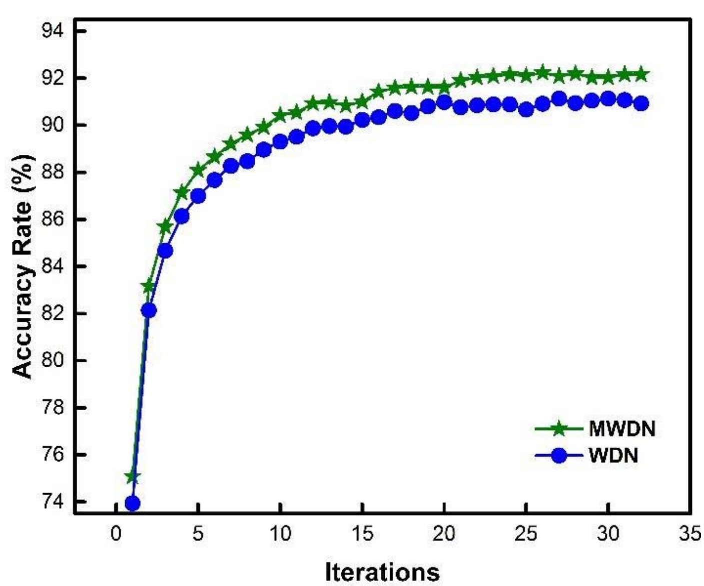

Fig. 3: The training process of different method

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Finally, we report the performance on the validation data of MNIST and MNIST_FASION, a challenging task with different datasets. Using only a single network, two datasets classification can be accomplished simultaneously we investigate the effects of various combinations of different datasets for MWDN. The results are shown in Fig 3. We find that we can implement two classes to the same network with MWDN algorithm. Compared to other approach that use only single dataset as input, our approach even yields a boost.

VI. Conclusion

In this paper, we propose a novel and multi-tasks optical network named as the multi-wavelength diffractive network (MWDN). Based on plane wave propagation, our method can achieve comparable accuracy against the single-task network. We successfully apply MWDN to multi-tasks with different datasets distribution and provide a multi-wavelength method with different model size. In the future, we aim to develop a more effective network to achieve complex tasks and reach better performance.

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References Références Referencias

1. Jewell, and J. L., "Regenerative pulsations from an intrinsic bistable optical device," Applied Physics Letters, vol. 40, no. 4, pp. 291.
2. J. Kraitl, H. Ewald, and H. Gehring, "An optical device to measure blood components by a photoplethysmographic method," Journal of Optics A Pure & Applied Optics, vol. 7, no. 6, pp. 0-0.
3. Y. Liu, X. Lin, C. Wei, C. Zhang, and Y. S. Zhao, "3D-printed optical-electronic integrated devices," Science China Chemistry, 2019.
4. S. Kim, S. G. Menabde, V. W. Brar, and M. S. Jang, "Functional Midnfrared Polaritonics in van der Waals Crystals," Advanced Optical Materials, pp. 1901194, 2019.
5. M. Spencer, J. Eickholt, and J. Cheng, "A Deep Learning Network Approach to ab initio Protein Secondary Structure Prediction," Computational Biology & Bioinformatics IEEE/ACM Transactions on, vol. PP, no. 99, pp. 1, 2014.
6. X. Zhou, R. Takayama, S. Wang, T. Hara, and H. Fujita, "Deep learning of the sectional appearances of 3D CT images for anatomical structure segmentation based on an FCN voting method," Medical Physics, vol. 44, no. 10, pp. 5221, 2017.
7. C. Che, R. Lin, X. Zeng, E. Karim, G. John, and M. Xu, "Improved deep learning-based macromolecules structure classification from electron cryo-tomograms," Machine Vision & Applications.
8. X. S., R. Girshick, P. Doll¨¢r, Z. Tu, and K. He, "Aggregated Residual Transformations for Deep Neural Networks," IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 5987-5995, 2017.
9. D. Chao, C. L. Chen, K. He, and X. Tang, "Learning a Deep Convolutional Network for Image Super-Resolution."
10. D. Li, "Deep learning: from speech recognition to language and multimodal processing," Apspia Transactions on Signal & Information Processing, vol. 5, pp. -.
11. S. P. Singh, A. Kumar, H. Darbari, L. Singh, and S. Jain, "Machine translation using deep learning: An overview."
12. T. O. Kwok, and Y. K. Kwok, "On the design, control, and use of a reconfigurable heterogeneous multi-core system-on-a-chip."
13. T. F. Cianciulli, J. A. Lax, F. E. Cerruti, G. E. Gigena, H. J. Redruello, M. A. Orsi, J. A. Gagliardi, A. N. Dorelle, M. A. Riccitelli, and H. A. Prezioso., "COMPLEMENTARY VALUE OF TRANSTHORACIC ECHOCARDIOGRAPHY & CINEFLUOROSCOPIC EVALUATION OF MECHANICAL HEART PROSTHETIC VALVES," Echocardiography, vol. 21, no. 2, pp. 211-211, 2010.
14. A. F. Vincent, J. Larroque, W. Zhao, N. B. Romdhane, and D. Querlioz, "Spin-Transfer Torque Magnetic Memory As a Stochastic Memristive Synapse."
15. A. N. Tait, M. A. Nahmias, T. Yue, B. J. Shastri, and P. R. Prucnal, Photonic Neuromorphic Signal Processing and Computing: Springer Berlin Heidelberg, 2013.
16. C. Ríos, M. Stegmaier, P. Hosseini, D. Wang, T. Scherer, C. D. Wright, H. Bhaskaran, and W. H. P. Pernice, "Integrated all-photonic non-volatile multi-level memory," Nature Photonics.
17. R. A. Hut, N. Mrosovsky, and S. Daan, "Nonphotic Entrainment in a Diurnal Mammal, the European Ground Squirrel (Spermophilus citellus)," Journal of Biological Rhythms, vol. 14, no. 5, pp. 409-420.
18. K. Voutsas, G. Langner, J. Adamy, and M. Ochse, "A brain-like neural network for periodicity analysis," IEEE Transactions on Systems Man & Cybernetics Part B Cybernetics, vol. 35, no. 1, pp. 0-22.
19. M. Dülk, S. Fischer, M. Bitter, M. Caraccia, W. Vogt, E. Gini, H. Melchior, W. Hunziker, A. Buxens, and H. N. Poulsen, "Ultrafast all-optical demultiplexer based on monolithic Mach– Zehnder interferometer

with integrated semiconductor optical amplifiers," Optical & Quantum Electronics, vol. 33, no. 7-10, pp. 899-906.
20. X. Lin, R. Yair, Y. N. T., V. Muhammed, L. Yi, J. Mona, and O. Aydogan, "All-optical machine learning using diffractive deep neural networks," Science, pp. eaat8084-.
21. A. d. Campo, and C. Greiner, "SU-8: a photoresist for high-aspect-ratio and 3D submicron lithography," Journal of Micromechanics & Microengineering, vol. 17, no. 6, pp. R81-R95.
22. Y. Tian, P. Luo, X. Wang, and X. Tang, "Pedestrian Detection aided by Deep Learning Semantic Tasks."
23. L. Deng, "The MNIST Database of Handwritten Digit Images for Machine Learning Research [Best of the Web]," IEEE Signal Processing Magazine, vol. 29, no. 6, pp. p.141-142.
24. C. F. V. Loan, Computational Frameworks for the Fast Fourier Transform, 2011.

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IoT Based Sign Language Recognition System

By Raveen Wijayawickrama, Ravini Premachandra, Thilan Punsara & Achintha Chanaka

Abstract- Sign language is the key communication medium, which deaf and mute people use in their day-to-day life. Talking to disabled people will cause a difficult situation since a non- mute person cannot understand their hand gestures and in many instances mute people are hearing impaired. Same as Sinhala, Tamil, English, or any other language, sign language also tend to have differences according to the region. This paper is an attempt to assist deaf and mute people to develop an effective communication mechanism with non-mute people. The end product of this project is a combination of a mobile application that can translate the sign language into digital voice and IoT enabled, light-weighted wearable glove, which capable of recognizing twenty-six English alphabet, 0-9 numbers, and words. Better user experience provide with voice-to-text feature in mobile application to reduce the communication gap within mute and non-mute communities. Research findings and results from current system visualize the output of the product can be optimized up to 25%-35% with enhanced pattern recognition mechanism.

Index Terms: sign language, internet of things, gesture recognition, smart glove, recurrent neural network.

GJCST-A Classification: I.2.7

IOTBASEDSIGNLANGUAGERECOGNITIONSYSTEM

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Raveen Wijayawickrama [α], Ravini Premachandra [σ], Thilan Punsara [ρ] & Achintha Chanaka [Ѡ]

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I. Introduction

According to the latest statistics of the World Health Organization, 5% of the world population cannot hear a single word [1]. It is a tragedy, which leads them to mutism, since they can- not hear or learn words to speak. In conditions such as Apraxia of Speech, Cerebral Palsy and Aphasia people suffering from the inability to speak. To reduce this gap between mute and non-mute people, sign language will act as a bridge between them. Sign language is the main communication method for those who cannot express their voice. In such situations, they will need a communication mechanism to express their ideas with each other. As a non-mute person, sharing ideas with a mute person will cause a difficult situation for both. Because of one person cannot hear any sound and other one cannot understand the hand gestures. In such situations, society may have to make sure that deaf mute people can understand them very well. The more non-mute people do not understand them via sign language, the more they will avoid having human interaction with the community. There are 6909 distinct spoken languages in the world today [2]. Same as that, 125 sign languages use around the globe in different countries [3]. As an example of the nature of sign language, American Sign Language (ASL) is quite different from British Sign Language (BSL), even though English is the spoken language of both countries [2]. Within these 125 sign languages in the world, Sinhala sign language (SSL) also stands with other languages. With the "Smart community" concept, people tend to use technology to transform their natural lifestyle into more productive and positive ways. These devices sense and record user activities, predict their future behavior, and prepare everything one step ahead according to the user's preference or needs, giving him/her the most convenience, comfort, efficiency, and security. [4]

1. Computer vision-based method
2. Sensor-based method

Computer vision-based gesture recognition [5]can be less accurate and less comfortable to the end user since, it involves many aspects such as motion modeling, motion analysis, pattern recognition and machine learning [6]. Outdoor light states act a key role in vision-based gesture identification since, without proper light conditions, cameras will not be able to recognize the gestures and method through the image processing mechanisms. Considering the sensor-based hand gesture recognition mechanisms, different sensors provide set of data according to the joints and finger separation that characterizes a hand gesture. By obtaining these data, any movement can be represented as a sequence of frames. The remainder of the paper is arranged as follows: Section II elaborates the background survey including a theoretical comparison of existing SIGN LANGUAGE INTERPRETERS. Section III explains the approach of implementing the Glove and whole environment in detail. Section IV explains the Test results from the process and finally, Section V concludes the paper conclusion.

II. Background Review

Researches in the sign language recognition systems are mainly based on computer vision and sensor based recognition mechanisms. The image processing techniques [7] using the camera to capture the image/video. Examinations of the data with static images and identify the image using various algorithms and create sentences for that into the display [7] Camera place to direct the place that captures highest available hand movements, higher resolution camera take up more calculation time and hold more memory space. A deaf person always need a high performance camera permanently and cannot use in a public place.

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Though, computer vision technologies restricted in terms of their functionalities, many high performance techniques required with more expensive sensors which not only made the application more complex and expensive. The system was limited to an accurate background without any noise or disturbance.

Another research determines sign language recognition system using a hand glove. [8] [9] In this design, mute person need to wear a glove consist of 5 flex sensor for each finger and motion tracker. Data are directly coming from every 5 sensors and process sensor data with static data to produce sentences. It's using a neural network to increase the completion of the system. The main advantage of this system is the fast response in real-time applications. Its movable device and cost of the complete device is higher since the hardware used are expensive [9].

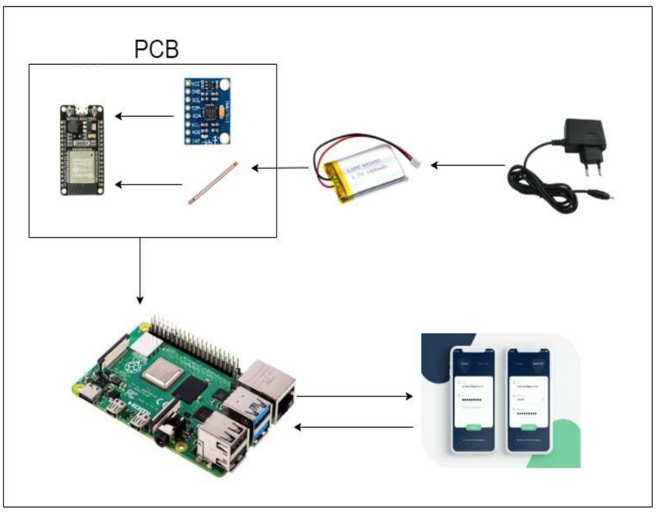

Fig. 1: System overview

In another research, researches developed a sign language recognition system using a portable Accelerometer (ACC) and Surface Electro Myogram (sEMG) [10]these sensors are used to detect the hand gesture. ACC used to capture movement information of hand and arms. These Sensor output signals are input to the computer and process to identify the hand gesture and provide speech and text with both [10]. But none of the above methods provides users with two-way communication and as well as a graphical picture of each sign. Our proposed system will be capable of delivering the two-way conversation with visualizing pictures of relevant signs in the app with a user-friendly manner.

Other than using flex sensors, a team of researchers used Potentiometer to extract the data from fingers [11]. Above system design was created to work with virtual reality applications like replacing the conventional input devices like joysticks in video games with the data glove. Also, the Robot control system to regulate machine activity at remote sensitive sites.

As per above-mentioned readings, it is clear that hand gesture recognition system for mute people is very essential to the current society, yet it has many issues to be addressed such like the mobility of the device, identifying and express full sentences other than words, power consumption and develop as a smart device.

III. Methodology

Proposed system is designed to identify and translate the hand gestures into a digital voice as final outcome. In implementation, system is consist of a software module and a hardware module. Accelerometer, flex sensors and printed circuit board includes in hardware module. As the initial step, system will capture the flex sensor and accelerometer readings. Record it one by one for each sign by using a push-button remote (push button). A push button is used to input the boundaries of a single data frame corresponding to a certain sign in the data stream. Number of data sets for one sign can be obtained and save them in a CSV file format. In the same manner different data sets for different signs (100) can be collected. These signs referred as mean data set. As the next step get overall CSV file set and calculate the mean value for each sign.

After getting the mean values, collection of single CSV files set for each different sign. For example, if there are 10 signs, there will be x axis data for each 10 signs and saved in one CSV file. Similarly, now there are 8 CSV files for for X,Y,Z z-axis and 5 flex sensors. In addition to that, recorded data set also included in the system. As previous this also has 8 CSV files for X,Y,Z axis and also for the 5 flex. The only difference here is it is not necessary to calculate the mean value. The next step is to identify the mean squared error (MSE). Using recorded data and the actual data set can calculate the MSE value.

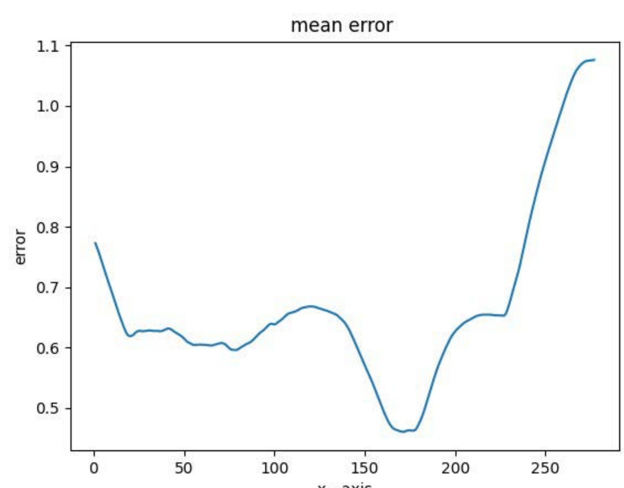

Fig. 2: Mean error

Up to this moment there are two different data sets available in the system (actual sign data set and recorded data set). According to the graph here, it visualize our data set which consists of the actual gesture capture with their mean values. In addition to that, data set which consists of the recorded data set also available. Now according to the figure 2 graph, comparison of 2 graphs can be made by shifting them. As above, shifting the frame one by one will lead to calculate the MSE value. As a assumption, assume recorded data set and it has 120 data points. Initially it's necessary to fix the actual sign size. It will range 0 to 80 and then check it. Then shift by one value and next 1 to 81 ranges and check it. Likewise shifting the actual sign graph on our recorded sign graph and calculate the MSE value. As a last step of first phase, data can be stored in an array. After comparing the graphs by shifting method MSE value array can be generated. After checking the complete graph, point of lowest value in graph can be identified as the point where consist the lowest error.

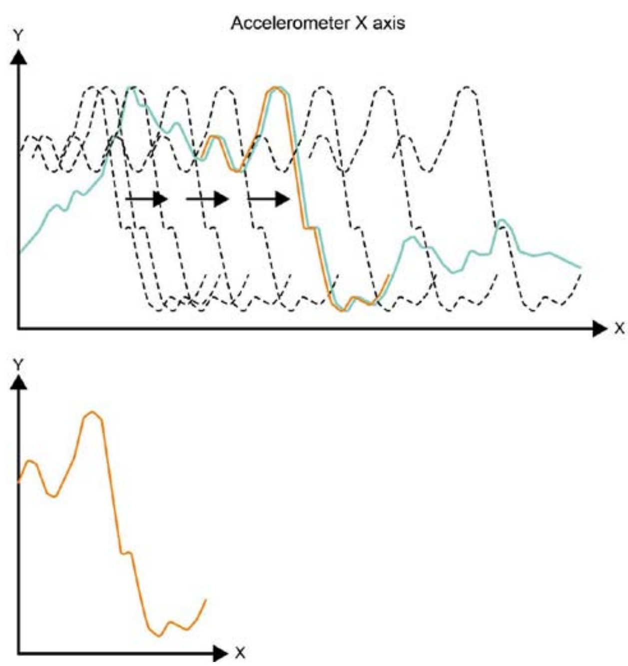

Fig. 3: Shifting the graph

Identification of fix value is essential since it used to compare the MSE values. To calculate this fix value, same two Graphs will be used. Actual one (for a one sign) and calculate the MSE value of it. In a perfect error-less scenario outcome should be 0.00. But obviously there is are range differences between same sign graphs. Because of that calculating this in several times we have to select a fix one. As the final results for the fix value we got the answer as 0.05. After getting fix value now it is easy to scale out our MSE values as following.

1. Ex- maximum error value = 0.05
2. If our minimum MSE value is (E) ≤ 0.05

This result can be accepted, since mean of the recorded data set is equal to the exact sign and very similar to the sign that we used to shift (Actual data set). We have eight CSV file up to now (both actual and recorded). This need to done to the same e CSV files also and we have to collect the results in several time for same graphs also to get a idea of the pattern that will take(ex R1, R1.1 R1.2). After getting results it can be visualize as below. After getting data from the sensors and calculating the MSE values, cost function will provide the processed data in to a Long short-term memory network (LSTM). Once the data received, LSTM will try to recognize a pattern with input data and give an output. If we consider 1,2,3,4 & 5 are five different signs, according to the below graph, output is identified as 1,2,3 &4. This is a perfect, error less situation since none of the other signs identified by accelerometer axis or flex sensors other than the original sign. It comes only if accelerometer axis and flex sensors identify the correct sign without any interference with other signs. If we check the output 5, it clearly visible all 8 sensors identify the output as "5" yet Y,Z axis and F3 sensor identified "5" with 3,4 signs as well. This is an error, yet it can be normalized, since once the same pattern identified by the LSTM network, it will keep the pattern in the memory. Whenever a similar pattern or pattern with minor changes identified by LSTM network it will give the output as pattern with most similarities.

Once a pattern is recognized through LSTM, processed data will feed in to a another LSTM network for smooth the outcome of the sentence. Smoothing the outcome is essential because from the first LSTM network we only get identified word series. Processing is essential for give a user-friendly outcome to the end user. After getting a complete, meaningful sentence from second LSTM network it will transmitted over WiFi to a mobile application. From mobile application identified sentence will be expose to the end user in voice format.

The designed Sign language recognition system has the capability of training an inexperienced user to the system with inbuilt training mode. Once a new user registered through the mobile application first time, user will be directed to the training mode. According to the given instructions user may complete the training in predefined time. Once the training session is completed, accuracy of new users hand gestures will be calculated and provide with percentage.

PCB Design

Customized PCB was designed to obtain the signals from 5 flex sensors and accelerometer with optimized space usage to reduce the weight of the device. Other than using whole modules, this PCB is designed with separate ICs, sensors and SMD components to reduce the space usage.

1. Esp wroom 32D IC

2. MPU 6050 Module
3. CP2102 (serial communication)

To build the serial communication we connect the CP2102 through a micro USB port. In such cases like, WiFi failure or battery power decrease we can directly connect the board and the Raspberry Pi via a micro USB cable. Also, we provide power, through the micro USB port. Data is directly coming from 5 flex sensors and MPU 6050 sensor. Through WiFi connection, data will transfer to the Raspberry Pi for processing.

When we take the data in live data will store in an array that is coming from module. This array size is depending on the largest size count on the mean data set. When the array count is fully then it will send for the process. Again for the same process before it storing 50% of data elements from the array will be deleted. Then the data will shift to the first elements and also adding. Then as in previous when the array count is fully then it will send for the process. This whole process will be evaluated when we catch live data.

IV. Test Results

Experiments were mainly conducted with the test graph results. For example, observe the sign 'Good morning'. For the 'Good morning' sign, we should obtain the mean data set and recorded data set. It will show in figure 6 and 7 here (For a one Axis).

X					Y					Z					F1					F2					F3					F4					F5					Output
1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	2
0	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0	0	3	0	0	3
0	0	0	4	0	0	0	0	4	0	0	0	0	4	0	0	0	0	4	0	0	0	0	4	0	0	0	0	4	0	0	0	0	4	0	0	0	0	4	0	4
0	0	0	0	5	0	0	0	4	5	0	0	3	0	5	0	0	0	0	5	0	0	0	0	5	1	0	0	0	5	0	0	0	0	5	0	0	0	0	5	5
0	0	0	0	5	0	0	0	4	5	0	0	3	0	5	0	0	0	0	5	0	0	0	0	5	1	0	0	0	5	0	0	0	0	5	0	0	0	0	5	5
0	0	0	0	5	0	0	0	4	5	0	0	3	0	5	0	0	0	0	5	0	0	0	0	5	1	0	0	0	5	0	0	0	0	5	0	0	0	0	5	5

Fig. 4: LSTM Result

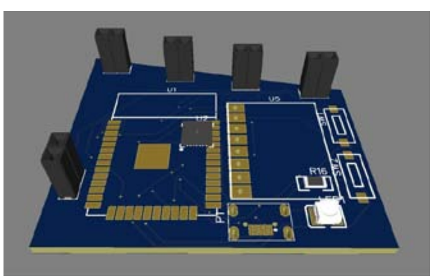

Fig. 5: PCB Design

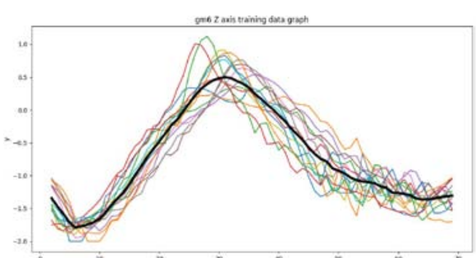

Fig. 6: Mean data set graph

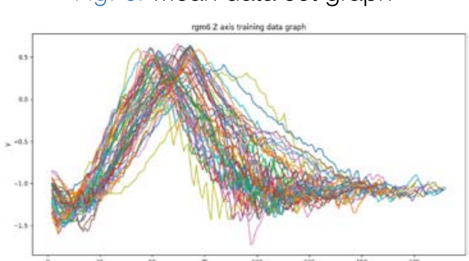

Fig. 7: Recorded data graph

$$\mathrm{MSE} = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2$$

Fig. 8: MSE Algorithm

After getting the mean values, recorded data set in the 'Good morning' shift the frame, one by one and calculate the MSE. Before that, we calculate the fix MSE value previous (mentioned in the methodology).

1. Ex- maximum error value = 0.05
2. If our minimum MSE value is (E) $\leq$ 0.05

If the results are agreed to above criteria, we can accept the results. It visualize, recorded data set the exact sign is very similar to the sign that we used to shift ('Good morning' sign).

- 1/N - Divide by the total number of Data points
- yi - Actual output value
- y^i - Predicted output value
- yi-y^i - The absolute value of the residual

V. Discussion

Study referencing shows the World Health Organization, Over 5% of the world's population or 466 million people have disabling hearing loss (432 million adults and 34 million children)[1]. In children under 15 years of age, 60% of hearing loss is attributable to preventable causes [1]. This figure is greater in low- and middle-income countries (75%) as matched to high-income countries (49%) [1]. Overall, preventable causes of childhood hearing loss include:

1. Infections such as mumps, measles, rubella, meningitis, cytomegalovirus infections, and chronic otitis media (31% [1].
2. Complications at the time of birth, such as birth asphyxia, low birth weight, prematurity, and jaundice (17%) [1].
3. Use of ototoxic medicines in expecting mothers and babies (4%) [1]. Others (8%)

Taking these matters of the impact of hearing problems in the world, it has been discovered that a solution to identify these sign language communicate and predict how two-way communication is done and how the new user familiar with the sign language using the training mode. Hence this research study is based on using machine learning to predict the variation of the signs and neural network to identify the specific signs by using the data. Two types of sensors are used to capture the data of a hand gesture. The flex sensor and accelerometer are used to capture the readings from a hand gesture in a multidimensional way. Five flex sensors are used to capture the finger movements using the resistance of the flex sensors located on every finger of the glove. Five flex sensors will be used for a single hand since the project focuses on hand gesturing of American Sign Language. The American Sign Language has been selected since the gesture of the language is only based mostly on a single hand. Furthermore, the accelerometer (GY-521) positioned on the top of the glove will be used to measure the acceleration force of the hand gesture. The data is taken by the sensor will be sent ESP wroom 32D sensor for further processing as well.

Captured data transmitted via MPU 6050 Module to Raspberry-Pi and it will be processed in artificial neural network [12]. In this process ANN's output will be a collection of words, letters or numbers which will not give a proper sense to the end user. To overcome this obstacle, Natural Language Processing mechanism can be used in the proposed system.

The overall application will be design from using Android studio and adobe XD for design interfaces. When considering the structure of mobile application, it has many interfaces to illustrate information to the user which is included different features;

- The device is connected to a mobile application through Bluetooth When open the application first-page display connect tab and home tab then press the connect button application relates to the main control system.
- Provide user-friendly interfaces for understanding sign language when considering this mobile application; it should be a special one because this application interacts with deaf persons. It provides clear interfaces for user.
- User can select modes.
    1. User Mode
    2. Training Mode
    3. Battery Level

After the connection, the mobile application with the main control system user can go to the home interface and it has user-mode tab and training mode tab if the user selected user mode user can communicate with other persons. Then user- selected training mode a new user can clearly get understanding of what is sign language and user can test whether how success the attempt of doing the signs in given time.

Provide text and animation for illustrate sign language Normal person is talking with the deaf person that voices are converting to the hand gestures and that gestures are display through the mobile application with text

Suggestion

1. X- axis - Data points
2. Y-axis - Processing time

This graph visualize the data processing speed of Intel core i7 processor and Raspberry Pi 4B.Green color graph illus- trates the data input without processing. Orange color graph illustrates the data processed through Intel core i7 (1065G7 CPU @ 1.50 GHz) processor. Blue color graph illustrates the Data processed through Raspberry Pi 4B (Broadcom BCM2711 SoC 1.5 GHz 64-bit quad-core ARM Cortex-A72). With the proposing method, input data rate will be reduced and sign graphs are checked with ¼ part of the complete sign in the beginning. Once the first ¼ of the sign is identified with cost function, rest of the sign will be checked.

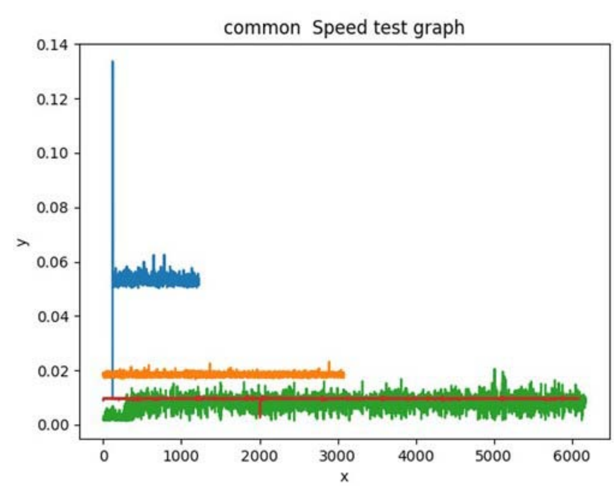

Fig. 9: Processing speed testing

According to the current method, once a sign reached to the cost function, complete sign's mean squared error will be calculate. If sign consist with 120 data points, MSE value should be calculated 120 times. In proposed method, a sign signal break into ¼ of full length. Once the mean value start to analyze the sign, first it check the ¼ of signal and verify whether it can identify the signal. If the first quarter can be identified, rest of the sign will be processed. Considering this method efficiency can be increased.

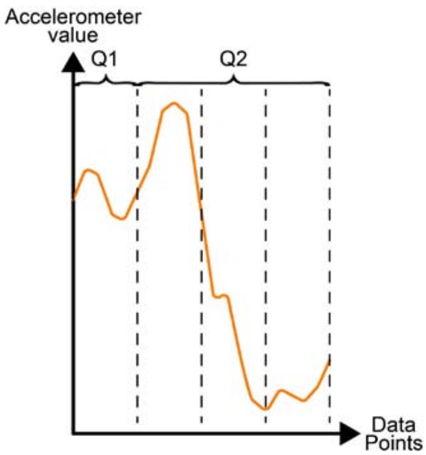

Fig. 10: Suggested method

VI. Conclusion

End product of this project is useful for handicapped mute community, which will develop a bridge between those who comprehend sign language and those who do not. Initial version of this product support the ASL. We described the method for obtaining hand gestures by several sensors including flex sensors. With use of NLP mechanisms data will be processed and trained to give a more accurate output. During our project we faced several challenges and problems including obtaining and processing data, yet we give our full strength to minimize the errors, since it will lead to minimize the communication gap among the disable community.

References Références Referencias

1. Solvang Iselin Ertzgaard, Naalsund Kristin, Tønder Sofie, Hansen Giske Sindberg, Hagan Tobias Bang, Mnyanyi Cosmas, Tronstad Tron Vedul, Nkya Aslam, and Øygarden Jon. Prevalence of hearing impairment among primary school children in the kilimanjaro region within tanzania. International Journal of Pediatric Otorhinolaryngology, 130:109797, 2020.
2. Mizanur Rahman, Md Salah Uddin, Md Samaun Hasan, Apurba Ghosh, Sadia Afrin Boby, Arif Ahmed, Shah Muhammad Sadiur Rahman, and Shaikh Muhammad Allayear. Anatomical analysis between two languages alphabets: Visually typographic test transformation in mor- phological approaches. In International Conference on Advances in Computing and Data Sciences, pages 330–339. Springer, 2020.
3. Dolors Rodr ´ıguez-Mart´ın, Catalina Rodr´ıguez-Garc´ıa, and Anna Falco´- Pegueroles. Ethnographic analysis of communication and the deaf com- munity's rights in the clinical context. Contemporary nurse, 54(2):126– 138, 2018.
4. Xu Li, Rongxing Lu, Xiaohui Liang, Xuemin Shen, Jiming Chen, and Xiaodong Lin. Smart community: an internet of things application. IEEE Communications magazine, 49(11):68–75, 2011.
5. Ying Wu and Thomas S Huang. Vision-based gesture recognition: A review. In International Gesture Workshop, pages 103–115. Springer, 1999.
6. Amy Cyphert. Tinker-ing with machine learning: The legality and consequences of online surveillance of students. Nevada Law Journal, 20, 2020.
7. Rini Akmeliawati, Melanie Po-Leen Ooi, and Ye Chow Kuang. Real- time malaysian sign language translation using colour segmentation and neural network. In 2007 IEEE Instrumentation & Measurement Technology Conference IMTC 2007, pages 1–6. IEEE, 2007.
8. Priyanka Lokhande, Riya Prajapati, and Sandeep Pansare. Data gloves for sign language recognition system. International Journal of Computer Applications, 975:8887, 2015.
9. Kirsten Ellis and Jan Carlo Barca. Exploring sensor gloves for teaching children sign language. Advances in Human-Computer Interaction, 2012, 2012.
10. Yun Li, Xiang Chen, Xu Zhang, Kongqiao Wang, and Z Jane Wang. A sign-component-based framework for chinese sign language recognition using accelerometer and semg data. IEEE transactions on biomedical engineering, 59(10):2695–2704, 2012.
11. Aaisha Parveen and Rohitha UM. Microcontroller based hand gesture recognition system using flex sensor for disabled people. International Journal of Computer Applications, 975:8887.
12. A Cochocki and Rolf Unbehauen. Neural networks for optimization and signal processing. John Wiley & Sons, Inc., 1993.

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13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

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 soundly written procedures segment allows a capable scientist to replicate 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 to give the least amount of information that would permit another capable scientist to replicate 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 section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show 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:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the 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—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and 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 as 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. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give 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 manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit 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 section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an 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 implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully 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 the prospect, and let it drop at that. Make a decision as to whether each premise is supported or 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.

- o You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- o Give details of all of your remarks as much as possible, focusing on mechanisms.
- o Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- o One piece of 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?
- o Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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