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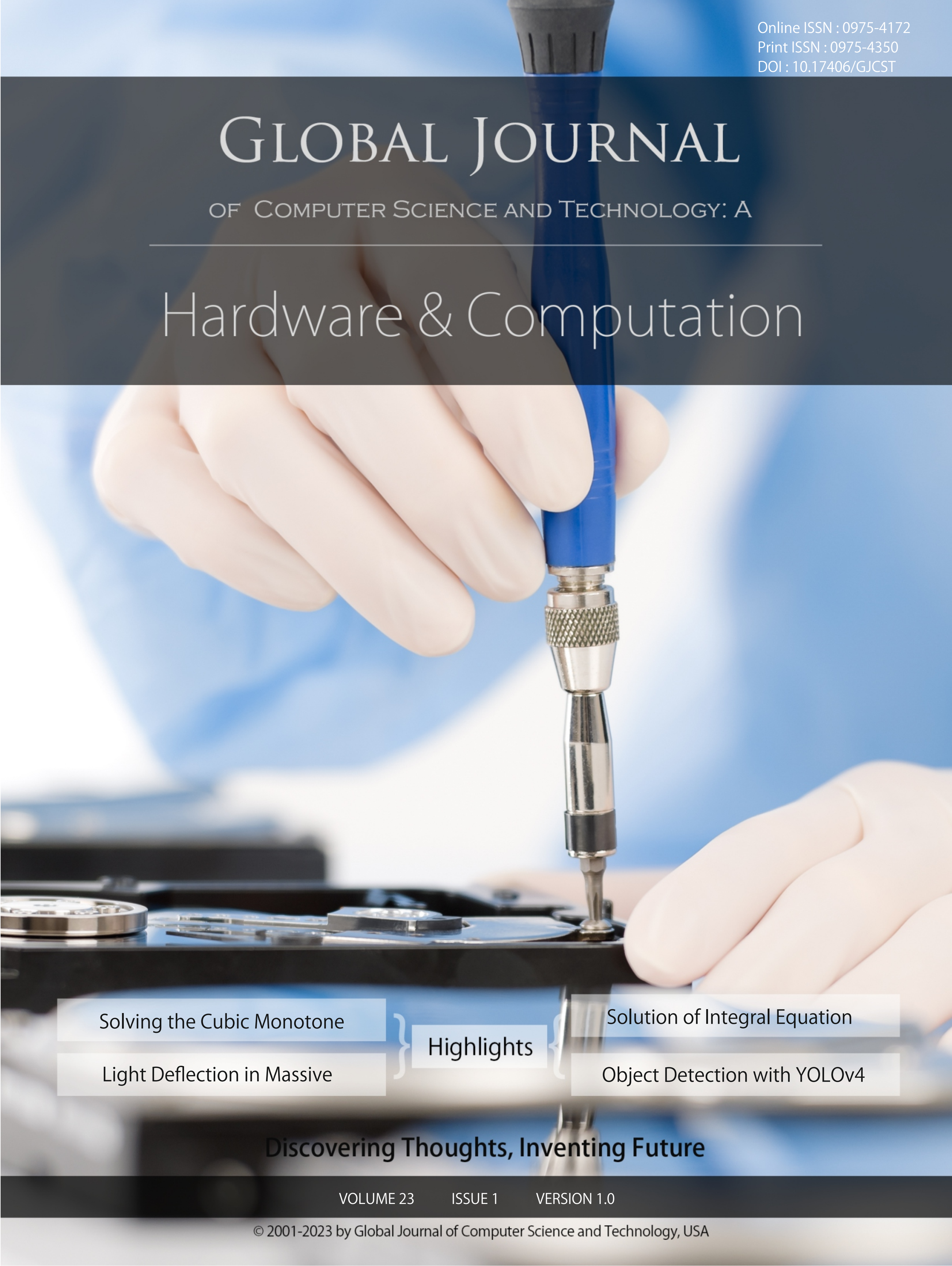

Highlights

Solving the Cubic Monotone

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Solution of Integral Equation

Object Detection with YOLOv4

Discovering Thoughts, Inventing Future

VOLUME 23 ISSUE 1 VERSION 1.0

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# Solving the Cubic Monotone 1-in-3 SAT Problem in Polynomial Time

By Omar Kettani
*Mohammed V University*

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The present paper shows that the Cubic Monotone 1-in-3 SAT Problem can be solved in polynomial time and, therefore prove that the conjecture P=NP holds.

*Keywords: exact 3-satisfiability; cubic Monotone 1-in-3 SAT; $K_6$ free graph; polynomial time; P vs. NP.*

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SOLVINGTHECUBICMONOTONE1IN3SATPROBLEMINPOLYNOMIALTIME

*Strictly as per the compliance and regulations of:*

# Solving the Cubic Monotone 1-in-3 SAT Problem in Polynomial Time

Omar Kettani

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**The present paper shows that the Cubic Monotone 1-in-3 SAT Problem can be solved in polynomial time and therefore prove that the conjecture P=NP holds.**

*Keywords: exact 3-satisfiability; cubic Monotone 1-in-3 SAT; $K_6$ free graph; polynomial time; P vs. NP.*

## I. Introduction

The Boolean satisfiability problem [1], often abbreviated as SAT, stands as one of the most fundamental and intriguing challenges in Computer Science and Mathematics. At its core, SAT revolves around a deceptively simple question: Can we find an assignment of truth values (true or false) to a set of Boolean variables that makes a given logical expression or formula true? Despite its apparent simplicity, SAT is an NP-complete problem, meaning that it belongs to a class of computational problems for which no known efficient algorithm exists to find a solution in polynomial time. This complexity has profound implications, as SAT problem-solving techniques have applications across various domains, from hardware and software verification to artificial intelligence and optimization.

The X3SAT problem is a variant of Boolean Satisfiability Problem (SAT). Unlike traditional SAT, which deals with Boolean variables and formulas, X3SAT introduces a more intricate layer of complexity by incorporating higher-order logical expressions. In X3SAT, the objective is to determine whether there exists an assignment of truth values setting exactly one literal to 1 in each clause of a given formula, which consists of conjunction of clauses, each containing exactly three literals (positive or negated Boolean variables). This three-literal requirement lends X3SAT its name and sets it apart from its predecessor, SAT.

The goal of the present paper is to solve efficiently the exact 3-satisfiability problem (X3SAT) which is known to remain NP-complete for expressions where every variable has precisely three occurrences, even in the absence of negated variables (Cubic Monotone 1-in-3 SAT Problem ) [2] [3].

XSAT and X3SAT have been recently investigated in [3, 4, 5, 6]. However the first breakthrough result [7] provides an algorithm deciding XSAT in $O(2^{0.2441n})$ time, for input formulas over n variables. This bound has been improved to $O(2^{0.2325n})$ [8]. In [9], Porschen presented an upper bound of $O(2^{0.1625n})$ for the minimum-weight exact 3-satisfiability problem (MINW-X3SAT) getting as input 3-CNF formulas over n real-valued weighted propositional variables. The best known-result for unweighted X3SAT outputs a solution in $O(2^{0.1379n})$ time [9]. In [10], the author proposed a heuristic approach for solving the Cubic Monotone 1-in-3 SAT Problem.

On the other hand, the P versus NP problem is a prominent unsolved question in Computer Science. It is well known that if there exists an efficient algorithm for any one of the NP-complete problem then, P = NP. In this work, we show that the Cubic Monotone 1-in-3 SAT Problem, which is an NP-complete problem is also in P and therefore, we prove that the conjecture P=NP holds.

*a) Some definitions*

A literal in Boolean logic is the basic building block of a logical expression. It can represent a Boolean variable or its negation (complement). In other words, a literal is either a positive occurrence of a variable (e.g., a) or its negation (e.g., ¬a), where "a" is a Boolean variable. Literals are the atomic elements that make up Boolean formulas and play a fundamental role in logical operations, such as conjunction (AND) and disjunction (OR).

A clause is a disjunctive statement in Boolean logic, typically represented as a logical OR operation between literals. Clauses express a condition where at least one of the literals within the clause must be true for the entire clause to be considered true. Clauses are essential components of Boolean formulas and often used to represent specific conditions or constraints within logical expressions. In many applications, clauses are combined to form more complex Boolean formulas, with the satisfaction of all clauses collectively determining the overall truth value of the formula.

A conjunctive normal form (CNF) formula is a specific representation of a Boolean expression in propositional logic. It is characterized by being a

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conjunction (logical AND) of clauses, where each clause is a disjunction (logical OR) of literals.

A truth assignment is a function that assigns a truth value (true or false) to each variable within a logical expression or formula. It provides a specific interpretation or valuation of the variables, indicating whether each variable is considered true or false under that assignment. The primary purpose of a truth assignment is to determine the truth value of the entire logical expression based on the truth values assigned to its constituent variables.

A logical expression or formula is said to be satisfiable if there exists at least one truth assignment of its variables that causes the entire expression to evaluate to true. In other words, the formula is satisfiable if it can be made true under some interpretation of its variables.

Conversely, if there is no truth assignment makes the formula true, it is considered unsatisfiable or contradictory.

The exact 3-satisfiability problem (X3SAT) asks in its decision version, whether there exists a truth assignment t: {0, 1}→V (F ), setting exact one literal to 1 in each clause of F . We call such an assignment t an x-model, and we denote with X3SAT the set of all exact satisfiable 3-CNF formulas. In the search version of X3SAT one has to decide whether F ∈ X3SAT, and in the positive problem to find an x-model of F. X3SAT restricted to expressions where every variable has exactly three occurrences, without negated variables is called Cubic Monotone 1-in-3 SAT Problem [3].

The rest of this paper is organized as follows. In the next section, proposition 1 establishes the equivalence between the Cubic Monotone 1-in-3 SAT problem, and a system of linear equations over binary variables. Some proprieties of the associated graph of a given formula are described in proposition 2. Proposition 3 proves that the Cubic Monotone 1-in-3 SAT problem has a solution if and only if its related graph on n vertices has an independence number n/3. Proposition 4 proves that if the associated graph of a given F∈ Cubic Monotone 1-in-3 SAT problem has $K_6$ (the complete graph on 6 vertices) as an induced subgraph, then F is not satisfiable. Proposition 5 proves that minimum degree 3 and maximum degree 6, $K_6$ free graph has an independence number of at least n/3. In proposition 6 it is proved that F is satisfiable if and only if G is a $K_6$-free graph. In proposition 7 and its corollary, the main result of this work is established. Finally, the conclusion of the paper is summarized in the last section.

*Proposition 1 [10]:*

Finding an x-model of F∈ Cubic Monotone 1-in-3 SAT problem (i.e. there exists a truth assignment x setting exactly one literal to 1 in each clause of F) is equivalent to solving the system of linear equations Ax=b, over binary variables $x \in \{0, 1\}^n$, where A is the mxn matrix defined by:

$A_{ij}=1$ if literal j appears in clause i

$A_{ij}=0$ otherwise

and b is the m vector $b=(1,....,1)^t$, m times.

*Proof:*

Clearly, x is a model of F∈ Cubic Monotone 1-in-3 SAT problem is equivalent $\forall i=1...m, \sum_{j=1}^{n} A_{ij}x_j=1$,

Which is equivalent to Ax=b, over $\{0, 1\}^n$

Notice that F∈ Cubic Monotone 1-in-3 SAT problem implies that the number of clauses m=n=3p, where p is an integer. Indeed: Ax=b implies that $||Ax||^2=||b||^2$,

Let $x=\sum_{j\in J} c^j$ where $J=\{j\in\{1,..,n\}\ x_j=1\}$ and $(c^j)_{j}\in\{1,..,n\}$ is the canonical basis of $R^n$.

Then $Ax=\sum_{j\in J} A^j$ where $A^j$ is the $j^{th}$ column of A matrix.

Then $||Ax||^2=||\sum_{j\in J} A^j||^2=m$

Since $\forall i,j\in JxJ\ A^iA^j=0$ because $\sum_{j\in J} A^j=b$ and $||A_j||^2=3, \forall j=1...n$

Then necessarily $3|J|=m=3p$ where $p=|J|$: m is necessarily a multiple of 3.

On the other hand, let $N_1$ be the number of ones in A matrix.

Since F∈ Cubic Monotone 1-in-3 SAT, if we count row by row, then we obtain $N_1 = 3m$, and if we count column by column, then we obtain $N_1 = 3n$.

Thus m=n=3p for any formula F∈ Cubic Monotone 1-in-3 SAT.

*Definition:*

Let F∈ Cubic Monotone 1-in-3 SAT problem, and matrix A as defined in proposition 1. Define its associated graph G=(V, E) of F by:

V is the set of n column matrix $A^j$ of A, for j=1...n .

$$E=\{(A^i,A^j) \in V\times V / A^i . A^j \neq 0\}$$

*Proposition 2:*

Let F∈ Cubic Monotone 1-in-3 SAT problem, A its associated matrix and G its associated graph on n vertices, then minimum degree of G is 3, maximum degree of G is 6.

*Proof:*

Since each line of matrix A contains three ones, and each column of matrix A contains three ones the maximum degree of each vertex of G is 6, since each $A^j$ is such $A^j . A^i \neq 0$ with at most 6 $A^i$. Note also that minimum degree of G is 3.

Because for all i=1...n, $3 \leq |\{A^i \in V, \exists A^j \in V / A^i . A^j \neq 0\}| \leq 6$: The minimum possible of adjacent columns to a given column $A^j$ is 3 and the maximum possible of adjacent columns to a given column $A^j$ is 6.

*Proposition 3:*

Let F∈ Cubic Monotone 1-in-3 SAT, A its associated matrix, G its associated graph on n vertices and α(G) denotes its independence number. Therefore:

1. α(G)≤n/3
2. F is satisfiable if and only if α(G)=n/3

*Proof:*

Indeed, let S be a set of mutually independent columns of A.

We will prove that $|S| \leq n/3$.

Assume, for the sake of contradiction, that the cardinality of S is greater than n/3. That is, |S| > n/3.

Now, each column in A has three ones, and selecting a column in S corresponds to selecting three ones from the rows associated with that column. Since |S| > n/3, we are selecting more than n/3 columns from A.

Consider the rows in A. Each row has exactly three ones. If we select more than n/3 columns (which implies we are choosing more than n/3 sets of three ones), by the Pigeonhole Principle, at least one row must have more than one of the ones selected.

However, we are assuming that S consists of independent columns. This means that for any selected set of columns, no row should have more than one of its ones selected. Therefore, our assumption that |S| > n/3 leads to a contradiction because it would require selecting more than n/3 sets of three ones from the rows, violating the independence condition.

Hence, by contradiction, we conclude that the cardinality of S cannot be greater than n/3. In other words, |S| ≤ n/3, thus α(G)≤ n/3.

If F is satisfiable, then for all i=1...n, $\sum_{j=1}^{n} A_{ij}x_j=1$, by proposition 1.

Let $x=\sum_{j\in J} c^j$ where $J=\{j\in\{1,..,n\}\ x_j=1\}$ and $(c^j)_{j\in\{1,..,n\}}$ is the canonical basis of $R^n$.

Then $Ax=\mathbf{A}\sum_{j\in J} c^j=\sum_{j\in J} A^j$ where $A^j$ is the $j^{th}$ column of A matrix.

$\forall(i,j)\in J\times J\ A^i . A^j=0$ otherwise $Ax\neq b$

since $\|Ax\|^2=\|\sum_{j\in J} A^j\|^2=\sum_{j\in J}\|A^j\|^2=n$, then $3|J|=n$ , because $\|A^j\|^2=3$ for j=1...n.

since $3|J|=n$, then $|S|=|J|=n/3$.

Hence, by proposition 3) i), α(G)=n/3.

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Therefore, if F is satisfiable, then its associated graph G on n vertices has an independence number $\alpha(G)=n/3$.

*The Converse is also True:*

Suppose the associated graph of on n vertices of F∈ Cubic Monotone 1-in-3 SAT problem has an independence number n/3.

Then, there exists S such: $\forall(i,j)\in S\times S$, $A^i . A^j=0$ and $|S| = n/3$.

Let's assume that $Ax \neq b$. This means that there exists at least one element in the vectors Ax and b that is not equal. In mathematical terms:

$\exists i: (Ax)_i \neq b_i$.

Now, let's analyze the elements of Ax and b:

Vector b is an nx1 vector of ones. This means that every element in b is equal to 1.

Vector Ax results from multiplying matrix A (with its specified properties) by vector x, where $x_j = 1$ if and only if column $A^j$ is in S.

Given that A has three ones in each column and three ones in each row, and S is a set of independent columns of A with cardinality $|S| = n/3$, when you compute Ax, we effectively sum up the selected columns from A, each selected column contributes exactly three 1s to Ax.

So, for each element $(Ax)_i$, it represents the sum of three 1s (because there are three ones in each selected column). Now, let's consider $b_i$, which equals to 1 for every element.

Now, consider the contradiction.

1. Let's assume there exists an index i such that $(Ax)_i \neq b_i$.
2. We know that for each element in Ax, it is the sum of three 1s from the selected columns.
3. We also know that $b_i$ equals to 1 for every element.

So, if $(Ax)_i \neq b_i$, it implies that the sum of three 1s (from the selected columns) is not equal to 1.

However, this contradicts the properties of A and the selection of S. Since A has three ones in each column, and S is chosen to be a set of independent columns, the sum of three 1s from the selected columns must always equal 1, as every element in b is 1.

Therefore, our assumption that $(Ax)_i \neq b_i$ leads to a contradiction. Thus, we can conclude that Ax must be equal to b for all elements, and the assumption that $Ax \neq b$ is false. Therefore, $Ax = b$ and by proposition 1, F is satisfiable.

Another way to prove this implication consists to remark that vector Ax (which is the result of multiplying matrix A by vector x, where $x_j = 1$ if and only if column $A^j$ is in S) is the sum of n/3 mutually independent columns of A. Since each column of A contains three ones, this sum equals b. Therefore, $Ax = b$ and, by proposition 1, F is satisfiable.

*Proposition 4:*

Let F∈ Cubic Monotone 1-in-3 SAT problem, A its associated matrix and G its associated graph on n vertices ($n\geq 6$). Therefore if $K_6$ (the complete graph on six vertices) is an induced subgraph of G, then F is not satisfiable (i.e., there exists no truth assignment setting exactly one literal to 1 in each clause of F).

*Proof:*

Let S be a maximum independent set of G. We will show that $|S| < n/3$ by contradiction. Suppose that $|S| >= n/3$. Then, there are at least n/3 vertices in G that are not adjacent to any other vertex in S. Since G contains $K_6$ as an induced subgraph, there must be a triangle T in G where all three vertices are not in S. But, this is a contradiction, because the three vertices of T would be adjacent to at least n/3 other vertices in G. This would violate the maximum degree condition of G, which states that all vertices must have a degree at most 6. Therefore, our original assumption must have been wrong, and $|S|$ must be less than n/3.

*Conclusion:*

Every graph with maximum degree 6 and minimum degree 3, such that G contains $K_6$ as an induced subgraph, has an independence number less than n/3. Therefore, F is not satisfiable by proposition 3.

Another way to prove this proposition consists of partitioning V into n/3 disjoint triangles and considering:

$$V=\cup T_i \quad \text{where } T_i \text{ is a triangle in V such } \forall\, i,j=1,\dots,n/3$$

$$T_i \cap T_j = \Phi. \quad i=1,\dots,n/3$$

Note that n/3-2 triangles contribute to at most one vertex in the maximum independent set. Therefore, if G contains $K_6$ as an induced subgraph, then after a possible permutation of columns of A, we have: $\exists$ i, j=1,…,n/3, $G[T_i, T_j]$ is isomorphic to $K_6$, then $\alpha(G[T_i, T_j])=1$ and $\alpha(G)\leq n/3-2+1= n/3-1< n/3$, hence F is not satisfiable, by proposition 3.

*Proposition 5:*

Let G be a $K_6$-free graph and a graph on n vertices ($n\geq 6$), with minimum degree 3 and maximum degree 6 then the independence number of G is at least n/3.

*Proof:*

We will prove by induction on n that the independence number of G is at least n/3:

Base Case ($n = 6$):

In this case, the graph is $K_6$-free graph and has an independence number of at least 2, which is greater than n/3 (which is 6/3). Therefore, the base case holds.

*Inductive Hypothesis:*

Assume that for some integer $k \geq 6$, the independence number of any $K_6$-free graph with minimum degree 3, maximum degree 6, and n vertices (where $6 \leq n \leq k$) is at least n/3.

*Induction Step:* Now, we will prove that the claim holds for a graph with k + 1 vertices.

Consider a $K_6$-free graph G with minimum degree 3, maximum degree 6 on (k + 1) vertices. Let v be any vertex in G. Let I denote the maximum independent set in the graph G (without vertex v). Let N(v) represents the set of neighbors of v), we have two cases to consider:

- *Case 1:* $|N(v) \cap I| > 0$. Let w denote any vertex in $N(v) \cap I$.
  Removing w and v from graph G will leave us with a $K_6$-free graph on k-1 vertices that satisfies the given conditions. Since the graph on k-1 vertices satisfies the induction hypothesis, its independence number is at least (k-1)/3. Adding w back to this independent set I and adding v back to G, we have an independent set of size at least (k-1)/3+ 1, greater than or equal to (k + 1)/3.
- *Case 2:* $|N(v) \cap I| = 0$.
  In this case, removing v from graph G will leave us with a $K_6$-free graph on k vertices that satisfies the given conditions. Since the graph on k vertices satisfies the induction hypothesis, its independence number is at least k/3. Adding v back to this independent set, we have an independent set of size at least k/3+ 1, greater than or equal to (k + 1)/3.

In all cases, we have shown that the independence number of G is at least (k + 1)/3.

By induction, we have proven that if G is a $K_6$-free graph on n vertices, with minimum degree 3 and maximum degree 6, then its independence number is at least n/3.

Another way to prove this result is to use the following contrapositive-argument:

*Base Case (n = 6):*

If G has six vertices and has less than 6/3 = two independent vertices, then G must contain $K_6$ as an induced subgraph because the only way to have fewer than two independent vertices = one independent vertex is that G must contain $K_6$.

*Induction Hypothesis:*

Assume that the statement is true for all n < k, where $k \geq 6$. That is, for any graph G with a maximum degree of 6, a minimum degree of 3, and n vertices, if G has fewer than n/3 independent vertices, then G contains $K_6$ as an induced subgraph.

*Inductive Step:*

Now, consider a graph G with a maximum degree of 6, a minimum degree of 3, and n vertices, where n = k. If G has n/3 independent vertices, we will show that this implies the existence of a $K_6$ as an induced subgraph within G.

Let I be a maximum independent set of G, and let v be an arbitrary vertex in I.

Define G' as the subgraph obtained by removing vertex v from G (G' = G - {v}). G' still has a maximum degree of 6 and a minimum degree of 3.
Now, we need to show that G' contains $K_6$ as an induced subgraph.

Since G' has fewer than n/3-1<(n-1)/3 independent vertices, (when we remove vertex v, we reduce the number of independent vertices by one because vertex v is not part of the independent set I. ) then, by the induction hypothesis, G' contains $K_6$ as an induced subgraph.

Thus, by the induction hypothesis, G' contains $K_6$ as an induced subgraph.

Since G' contains $K_6$ as an induced subgraph, G also contains $K_6$ as an induced subgraph because it contains G' as a subgraph.

Therefore, by induction, we have demonstrated that if G is a graph with a maximum degree of 6, a minimum degree of 3, and fewer than n/3 independent vertices, then G contains $K_6$ as an induced subgraph.

*Proposition 6:*

Let F∈ Cubic Monotone 1-in-3 SAT problem, A its associated matrix and G its associated graph on n vertices ($n \geq 6$). Therefore, F is satisfiable if and only if G is a $K_6$-free graph.

*Proof:*

First, we will prove that if G is a $K_6$-free graph then F is satisfiable (i.e. there exists a truth assignment setting exactly one literal to 1 in each clause of F). This is an immediate consequence of propositions 5 and 3: Since G is a $K_6$-free graph then its independence number is at least n/3 by proposition 5. However, by proposition 3) i), this independence number is at most n/3. Therefore, the independence number of G is equal to n/3, and by proposition 3) ii), F is satisfiable.

Now, the converse is also true: if F is satisfiable, then by proposition 4 and 3) ii), G is a $K_6$-free graph.

*Corollary:*

There exists a polynomial time algorithm that decides whether a formula F∈ Cubic Monotone 1-in-3 SAT problem is satisfiable.

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*Proof:*

Consider the following algorithm.

*Table 1:* Pseudo-Code of Proposed Algorithm 1

| |
|---|
| *INPUT:* F∈ Cubic Monotone 1-in-3 SAT problem |
| *Step 1:* Define the A matrix of F. |
| *Step 2:* Calculate det (A), if det (A) ≠0 then OUTPUT(' F has a unique solution: $x=A^{-1}b$ ') else go to step 3. |
| Step 3: Construct the associated graph G of F. |
| *Step 4:* Check if $K_6$ is an induced subgraph of G then OUTPUT(' F is not satisfiable') else OUTPUT('F is satisfiable') |

The correctness of this algorithm is an immediate consequence of the previous propositions. Indeed, it starts by computing det (A), if it is≠0 then the algorithm outputs the unique solution of the problem: the vector $x=A^{-1}b$ (proposition 1), else it constructs the associated G graph of the input formula. Then it checks if G contains $K_6$ as an induced subgraph. If G has $K_6$ as an induced subgraph then the algorithm outputs that F is not satisfiable else it outputs that F is satisfiable (i.e., there exists a truth assignment x setting exactly one literal to 1 in each clause of F) by proposition 6.

Steps 1 and 3 can be done in O ($n^2$) times. Step 2 requires O ($n^3$) times. Whereas step 4 requires O ($n^6$) times. Thus, the overall complexity of this algorithm is O ($n^6$).

*Proposition 7:*

Let G be a $K_6$ -free graph and a graph on n vertices (n≥ 6), with minimum degree 3 and maximum degree 6 then G is a $P_4$–indifference graph and a block graph.

*Proof:*

We will prove that G under (the given conditions) is a $P_4$–indifference graph i.e. G admits an acyclic orientation in which each induced $P_4$ is of the type: o->o->o->o.

To prove this, we can use induction.

*Base Case (n = 6):*

For n = 6, consider the graph G with minimum degree 3, maximum degree 6, and no induced $K_6$ subgraph.

Since G is $K_6$-free, there must be at least one vertex in G that is not adjacent to any other vertex in G. Let v be such a vertex.

Remove vertex v from G to obtain a subgraph G' with 5 vertices. Since G' has less than 6/3 = 2 independent vertices, by the previous arguments, G' contains an induced $K_4$ (complete graph on 4 vertices), and the orientation of the induced $P_4$ within G' follows the type o->o->o->o.

Now, add vertex v back to G and its edges to vertices in G'. The orientation of the edges involving v maintains the acyclic orientation with each induced $P_4$ being of the type: o->o->o->o.

Therefore, the base case holds

*Inductive Hypothesis:*

Assume that for any graph G with k vertices (k ≥ 6), with minimum degree 3 and maximum degree 6, the graph admits an acyclic orientation in which each induced $P_4$ is of the type: o->o->o->o.

*Inductive Step:*

Now, consider a graph G with k + 1 vertices (k ≥ 6), with minimum degree 3 and maximum degree 6. We will show that if G is $K_6$-free, it admits an acyclic orientation in which each induced $P_4$ is of the type: o->o->o->o.

Since G is $K_6$-free, it cannot contain an induced subgraph isomorphic to $K_6$. This means there must be at least one vertex in G that is not adjacent to any other vertex in G. Let v be such a vertex.

Remove vertex v from G to obtain a subgraph G'. G' has k vertices, minimum degree 3, and maximum degree 6. By the inductive hypothesis, G' admits an acyclic orientation in which each induced $P_4$ is of the type: o->o->o->o.

Now, consider the vertex v that was removed. Since G has minimum degree 3, v must be adjacent to at least three other vertices in G. Let w1, w2, and w3 be three such vertices.

Add vertex v back to G and orient the edges vw1, vw2, and vw3 as follows:

- vw1: o->o
- vw2: o->o
- vw3: o->o

Since G' admits an acyclic orientation in which each induced P4 is of the type: o->o->o->o, adding vertex v and the specified orientation of its edges will not create any directed cycles. Furthermore, any

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induced $P_4$ that includes v will have the selected orientation: o->o->o->o.

Therefore, admits an acyclic orientation in which each induced $P_4$ is of the type: o->o->o->o.

By induction, we have shown that any $K_6$-free graph on n vertices (n ≥ 6), with minimum degree 3 and maximum degree 6, admits an acyclic orientation in which each induced $P_4$ is of the type: o->o->o->o. This is because the structure of these graphs allows for the removal of vertices and subsequent addition without creating directed cycles or violating the specified orientation for induced $P_4$s.

Note that there exists a linear time algorithm LA for finding a maximum independent set in $P_4$ – indifference graphs [11].

To prove that G is a block graph, we will prove that every maximal 2-connected component (block) is a clique. This can be proven by contradiction.

A 2-connected component of a graph is a subgraph that remains connected even if any edge is removed. A maximal 2-connected component is a 2-connected component not adequately contained in any other 2-connected component. A clique is a subgraph in which every pair of vertices is adjacent.

*Proof by contradiction:*

Assume that there exists a $K_6$-free graph G with a minimum degree of 3 and a maximum degree of 6 such that not every maximal 2-connected component is a clique.

Let H be a maximal 2-connected component of G that is not a clique.

Since H is a maximal 2-connected component, it cannot be extended to a larger 2-connected component by adding any edges.

Since H is not a clique, there exists a pair of non-adjacent vertices u and v in H.

By the minimality of H, there must exist edges in G connecting u and v to vertices outside of H.

Let w be a vertex in G that is adjacent to u but not in H, and let z be a vertex in G that is adjacent to v but not in H.

Consider the subgraph of G induced by the vertices {u, v, w, z}.

Since G is $K_6$-free, this subgraph cannot be extended to a $K_5$ or a $K_6$ by adding edges to any other vertices in G. Therefore, the subgraph induced by {u, v, w, z} must be a $K_4$, a complete graph on four vertices.

However, this contradicts that H is a maximal 2-connected component, as adding the edge (u, v) to H would create a larger 2-connected component.

Therefore, our initial assumption that there exists a $K_6$-free graph G with a minimum degree of 3 and a maximum degree of 6 such that not every maximal 2-connected component is a clique must be false. Therefore, any $K_6$-free graph G with a minimum degree of 3 and a maximum degree of 6 must have the property that every maximal 2- connected component is a clique.

Note that there exists a polynomial time algorithm for finding a maximum independent set in block graphs [12].

*Corollary:*

There exists a polynomial time algorithm that decides whether a formula F∈ Cubic Monotone 1-in-3 SAT problem is satisfiable.

*Proof:*

*Consider the following algorithm:*

*Table 2:* Pseudo-Code of Proposed Algorithm 2

| |
|---|
| *INPUT:* F∈ Cubic Monotone 1-in-3 SAT problem |
| *Step 1:* Define the A matrix of F. |
| *Step 2:* Calculate det (A), if det (A)≠0 then OUTPUT(' F has a unique solution: $x=A^{-1}b$ ') else go to step 3. |
| *Step 3:* Construct the associated graph G of F. |
| *Step 4:* Check if $K_6$ is an induced subgraph of G then OUTPUT ('F is not satisfiable') else goto step 5. |
| *Step 5:* Run LA algorithm with input G. |
| if α (G)=n/3 then OUTPUT('F is satisfiable') else OUTPUT('F is not satisfiable') |

The correctness of this algorithm is an immediate consequence of the previous propositions. Indeed, steps 1 to 3 are similar to algorithm 1. In step 4, it checks if G contains $K_6$ as an induced subgraph. If G contains $K_6$ as an induced subgraph then the algorithm outputs that F is not satisfiable else it apply LA algorithm with input G (because in this case since G is $K_6$-free it is also $P_4$–indifference graph by proposition 7). Therefore,

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if α (G)=n/3 then it outputs that F is satisfiable (i.e. there exists a truth assignment x setting exactly one literal to 1 in each clause of F) by proposition 3, else it outputs that F is not satisfiable by proposition 4.

Steps 1 and 3 can be done in O($n^2$) times. Step 2 requires O($n^3$) times. Whereas step 4 requires O($n^6$) times. In step 5, LA algorithm run in O (n) time, thus the overall complexity of this algorithm is O ($n^6$).

*Example 1:*

n=6

F=(a1∨a3∨a4)∧ (a1∨a5∨a4)∧ (a1∨a2∨a6)∧ (a2∨a3∨a5)∧ (a5∨a3∨a6)∧ (a2∨a6∨a4)

$$A=\begin{pmatrix}1&0&1&1&0&0\\1&0&0&1&1&0\\1&1&0&0&0&1\\0&1&1&0&1&0\\0&0&1&0&1&1\\0&1&0&1&0&1\end{pmatrix}\qquad G=K_6$$

Therefore F is not satisfiable.

*Example 2:*

n=6

F=(a1∨a3∨a4)∧ (a1∨a6∨a4)∧ (a1∨a5∨a6)∧ (a2∨a3∨a5)∧ (a2∨a3∨a6)∧ (a2∨a5∨a4)

$$A=\begin{pmatrix}1&0&1&1&0&0\\1&0&0&1&0&1\\1&0&0&0&1&1\\0&1&1&0&1&0\\0&1&1&0&0&1\\0&1&0&1&1&0\end{pmatrix}\qquad \text{and } G \text{ is not isomorphic to } K_6$$

Therefore F is satisfiable and (a1,a2,a3,a4,a5,a6)=(1,1,0,0,0,0) is a truth assignment setting exactly one literal to 1 in each clause of F.

## II. Discussion

In this paper, two polynomial time algorithm that decides whether a formula F∈ Cubic Monotone 1-in-3 SAT problem is satisfiable were proposed. Since this problem is NP-complete, then it implies that the conjecture P=NP is true.

Future work will consist of developing an efficient implementation of the proposed algorithm to conduct some experiments on various instances of the problem.

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# Light Deflection in Massive Dyonic Black Holes

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*Abstract-* Following Rindler-Ishak method [1], we study the bending of light around general form of dyonic black holes in massive gravity [2]. We show that when the Schwarzschild-de Sitter geometry is taken into account, $\Lambda$ does indeed contribute to the bending of light.

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# Light Deflection in Massive Dyonic Black Holes

H. R. Fazlollahi

*Abstract-* Following Rindler-Ishak method [1], we study the bending of light around general form of dyonic black holes in massive gravity [2]. We show that when the Schwarzschild-de Sitter geometry is taken into account, Λ does indeed contribute to the bending of light.

## Introduction

Discovering dark energy as source of accelerating expansion of our universe [3], many efforts have gone into understanding its nature. One of the prime candidates is the cosmological constant Λ [4] which its effects on local phenomena such as null geodesics, time delay of light [5], and the perihelion precession [6] are studied. In these circumstance, local cases, many authors have investigated the effects of cosmological constant on the bending of light.

The argument for the non-influence of Λ was first discussed by Islam through investigating the null geodesic equation in a spherically symmetric space-time [7] and has been re-affirmed by other authors, see e.g. [8]. However, in the last decade, Rindler and Ishak [1], by considering the intrinsic properties of the Schwarzschild-de Sitter space-time proposed a new method for calculating the deflection angle of light. Also, different aspects of their method such as integration of the gravitational potentials and Fermats principle have been studied [9]. Sultana in [10] and Heydari-Fard et al [11] have investigated light bending in Kerr-de Sitter and Reissner-Nordstrom-de Sitter space-time through Rindler-Ishak method. Also, this method has been applied to investigate Mannheim-Kazanas solution of conformal Weyl gravity [12].

Dyonic black holes enjoy the duality of electric/magnetic

charges and possibly mass/dual mass [13]. In [14] is shown that two constants of a Taub-NUT system can be interpreted as a gravitating dyon with both ordinary mass and its dual where role of Nut charge is the mass duality such as the duality between electric and magnetic charges in the U(1) Maxwell theory [15]. Dyonic black hole and its properties have been investigated in literature (see [16]). In this letter, we take into account bending of light around dyonic black holes in massive gravity theory to examine massive gravity effects on light deflection.

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For static spherically symmetric space-time, the dyonic black hole in massive gravity, massive dyonic black hole, is given by [2].

$$ds^2 = -f(r)dt^2 + \frac{dr^2}{f(r)} + r^2(d\theta^2 + sin^2\theta\, d\phi^2) \qquad (1)$$

where

$$f = 1 + \frac{r}{l^2} - \frac{2m_0}{r} + \frac{q_E + q_M}{r^2} + m^2 \; \frac{cc_1}{2} r + c^2 c_2 \;\;, \qquad (2)$$

where $m_0$ is the total mass of dyonic black holes, m denotes the massive parameter, c, $c_1$ and $c_2$ are constants of model, $l^2 = -3/\Lambda$ and $q_E$ and $q_M$ identified as electric and magnetic charges, respectively.

The standard approach for calculating the bending angle is [17]

$$\Delta\phi = 2|\phi(\infty) - \phi(r_0)| - \pi \qquad (3)$$

where $r_0$ denotes the closest distance to the black hole. However, the space-time here is not asymptotically flat, and so we cannot use usual way to calculate the deflection angle of light around massive dyonic black hole. Surprisingly, the Rindler-Ishak method proposed in [1] gives new approach to calculate the deflection angle in an asymptotically non-flat space-time. Rindler and Ishak have shown that by considering the effects of cosmological constant on the geometry of space-time, one can obtain the contribution of Λ to the bending angle near massive celestial objects (for example see [20]). Using the Euler-Lagrange equations for null geodesics in equatorial plan, $\theta = \pi/2$, we obtain the following equation

$$\frac{d^2u}{d\phi^2} + u = -\frac{cc_1 m^2}{4} - c_2 c^2 m^2 u + 3m_0 u^2 - 2(q_E^2 + q_M^2)u^3, \qquad (4)$$

where $u \equiv 1/r$. For c = 0, and in the absence of electric and magnetic charges, we find the standard orbital equation for light bending in Schwarzschild-de Sitter space-time (see e.g. [18]).

The orbit that is usually considered as small perturbation of the undeflected straight line in flat space

$$r \sin\phi = R \qquad (5)$$

So according to the standard orbital equation of deflection of light, we have two different approaches to consider differential equation (4): first approximation case (see [1], [18]), where the small perturbation of the undeflected straight line (5) substituted into the right-hand terms of (4) or solving it by using a perturbation method up to the third order and consider a solution as

$$u = u_0 + \delta u_1 + \delta u_2 + \delta u_3 + \cdots \qquad (6)$$

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where $u_0 = \frac{\sin\varphi}{R}$ and corrections $\delta u_1$, $\delta u_2$ and $\delta u_3$ satisfy the following equations

$$\frac{d^2(\delta u_1)}{d\phi^2} + \delta u_1 = -\frac{cc_1 m^2}{4} + 3m_0 u_0^2 \qquad (7)$$

$$\frac{d^2(\delta u_2)}{d\phi^2} + \delta u_2 = 6m_0 u_0 \delta u_1 \qquad (8)$$

$$\frac{d^2(\delta u_3)}{d\phi^2} + \delta u_3 = 6m_0 u_0 \delta u_2 + 3m_0 \delta u_1^3 - c_2 c^2 m^2 u_0 + -2(q_E^2 + q_M^2) u_0^3 \qquad (9)$$

here we use perturbation method for small effects of electric-magnetic charge and massive parameter m on the deflection of light with respect to standard one.

Applying these approaches on equation (4) gives:

$$u_1 = \frac{1}{r} = -\frac{m^2 cc_1}{4} + \frac{\sin\phi}{R} + \frac{m^2 c^2 c_2}{2R}(\phi\cos\phi - \sin\phi) + \frac{m_0}{R^2}(1 + cos^2\phi) - \frac{q_E^2 + q_M^2}{4R^3}(\sin\phi\, cos^2\phi - 3\phi\cos\phi + 2\sin\phi)\,, \qquad (10)$$

$$u_2 = \frac{1}{r} = \frac{m_0}{R^2}\left(1 + \frac{3m_0^2}{R^2}\right) + \frac{\sin\phi}{R}\left(1 - \frac{m^2 c^2 c_2}{4} - \frac{5(q_E^2 + q_M^2)}{16R^2}\right) - \frac{m^2 cc_1}{2}\left(1 - \frac{3}{8}m^2 cc_1 m_0 + \frac{3m_0^2}{R^2}\right) + \frac{\phi\cos\phi}{2R}\left(m^2 c^2 c_2 + \frac{3}{2}m^2 cc_1 m_0 + \frac{3(q_E^2 + q_M^2)}{2R^2} - \frac{15m_0^2}{2R^2}\right) + \frac{m_0 cos^2\phi}{R^2}\left(1 - \frac{3m^2 cc_1 m_0}{2} + \frac{15m_0^2}{2R^2}\right) - \frac{3\phi\sin\phi\cos\phi\, m_0^2}{2R^2}\left(m^2 cc_1 - \frac{5m_0}{R^2}\right) - \frac{cos^2\phi\sin\phi}{4R^3}\left(q_E^2 + q_M^2 + 3m_0^2\right) - \frac{m_0^3}{2R^4}cos^4\phi \qquad (11)$$

where $u_1$ and $u_2$ are solutions of equation (4) for first approximation and perturbation method, respectively.

To obtain the one sided deflection angle at the point where

$\varphi \ll 1$, we obtain

$$u_1 \approx \frac{\phi}{R} + \frac{2m_0}{R^2} - \frac{m\ cc_1}{4}, \qquad (12)$$

$$u_2 \approx \frac{2m_0}{R^2}\left(1 + \frac{5m_0^2}{R^2}\right) + \frac{\phi}{R}\left(1 - \frac{9m^2 c^2 c_2}{2R^2} + \frac{3(q_E^2 + q_M^2)}{16R^2}\right) - \frac{m^2 cc_1}{4}\left(1 - \frac{3}{4}m^2 cc_1 m_0\right) + \frac{m^2 c}{4R}\left(3\phi m_0 c_1 + \phi cc_2 - \frac{12c_1 m_0^2}{R}\right). \qquad (13)$$

According to the Rindler-Ishak method, one able to compute angle $\psi$ between photon orbit direction d and direction of $\varphi$ = const. line, $\delta$, by the invariant formula (see Figure 1)

$$\cos\psi = \frac{g_{ij} d^i \delta^j}{\sqrt{g_{ij} d^i d^j}\sqrt{g_{ij}\delta^i \delta^j}} \qquad (14)$$

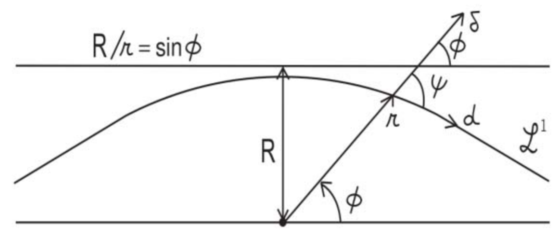


*Fig. 1:* The orbital map, light bending in the space-time of a black hole. The one-sided deflection angle is $\psi - \varphi \equiv \varepsilon$.

where $g_{ij}$ are the coefficients of the 2-metric on $\theta = \pi/2$ and t = const. surface. Substituting $d = (dr, d\varphi)$ and $\delta = (\delta r, 0)$ in Eq. (9), gives

$$\cos\psi = \frac{|dr/d\phi|}{\sqrt{(dr/d\phi)^2 + f(r) r^2}} \qquad (15)$$

or equivalently

$$\tan\psi = \frac{r\sqrt{f(r)}}{|dr/d\phi|} \qquad (16)$$

using equations (12) or (13) for m ≪ 1

$$\frac{dr}{d\phi} \approx -\frac{r^2}{R} \qquad (17)$$

finally, by substituting in equations (12) and (13), we find their corresponding expressions for the total deflection angle

$$2\epsilon_1 \approx \frac{4m_0}{R}\left(1 - \frac{2m_0^2}{R^2} + \frac{2m_0^2}{R^2}(q_E^2 + q_M^2)\right) - \frac{2R^3}{(m^2 R^2 cc_1 - 8m_0) l^2} + \frac{cm_0 m^2}{2R^3}\left(2R^2(cc_2 + c_1 m_0) - 3c_1 m_0 (q_E^2 + q_M^2)\right) - \frac{m^4 c^2 c_1}{128R}\left(c_1(q_E^2 + q_M^2)(m^2 R^2 cc_1 - 24m_0) + 8R^2(2cc_2 + c_1 m_0)\right) \qquad (18)$$

$$2\epsilon_2 \approx \frac{4m_0}{R}\left(1 - \frac{2m_0^2}{R^2} + \frac{2m_0^2}{R^4}(q_E^2 + q_M^2)\right) + \frac{m^2 c^2 c_2 m_0}{R} + \frac{R^3}{4m_0 l^2} + \frac{Rm^2 cc_1}{4} \qquad (19)$$

The deflection angle is modified by new terms containing the massive parameter and cosmological constant in both equations (18) and (19).

Canceling out massive parameter and cosmological constant effects gives the same results for both approaches in equations (18) and (19) as

$$2\epsilon \approx \frac{4m_0}{R}\left(1 - \frac{2m_0^2}{R^2} + \frac{2m_0^2}{R^4}(q_E^2 + q_M^2)\right) \qquad (20)$$

which equals to deflection light equation for charged Schwarzschild black holes.

The effect of the cosmological constant, electric charge and magnetic charge on deflection angle at small scales such as the solar system is expected to be negligible. So by using l → ∞ or Λ ≈ 0 and canceling out $q_E$ and $q_M$ from equations (18) and (19), we have

$$2\epsilon_1 \approx \frac{4m_0}{R}\left(1+\frac{cm^2}{4}(cc_2+c_1m_0)\right) \quad (21)$$

$$2\epsilon_2 \approx \frac{4m_0}{R}\left(1+\frac{c^2c_2m^2}{4}\right) \quad (22)$$

To find constraint on constant m, we use the observational data on light deflection by the sun, from long baseline radio interferometry [19]. According to this observational data, $\delta\phi_{LD} = \delta\phi_{LD}^{(GR)}(1+\Delta_{LD})$ with $\Delta_{LD} \leq$ ≤ 0.0002 ± 0.0008, where $\delta\phi_{LD}^{(GR)} = 1.7510$ arc sec. Assuming $\Delta_{LD}$ as the geometric effects of the conformal terms, the observational results constrain the two last equations as follows

$$m^2 \leq \frac{4\Delta_{LD}}{(c_2+c_1m_0)} \quad (23)$$

Assuming

$$m^2 \leq \frac{4\Delta_{LD}}{c_2} \quad (24)$$

where we set c = 1. This selection leads us to find massive parameter m as function of constants $c_1$ and $c_2$. Taking for R and m0 values of the radius and mass of the sun, $R_\odot \approx 6.95 \times 10^8$ m and $M_\odot \approx 1.99 \times 1030$ kg, we find following constraints on m according to our approaches, first approximation and perturbative method

$$|m| \leq \frac{0.0283}{\sqrt{1.99\times10^{30}c_1+c_2}} \quad \text{or} \quad |m| \leq \frac{0.0282}{\sqrt{c_2}} \quad (25)$$

In conclusion, in this letter, we have investigated the bending of light in the dyonic black holes in massive gravity.

Following Rindler-Ishak method, we have shown that when the geometry of the Schwarzschild-de Sitter space-time is taken into account, Λ indeed contributes to the light-bending in massive dyonic black holes. Also, using the observational data on bending of light by the sun and constant c = 1 leads us to find strong constraint on massive constant m.

Generally, if we assume that both approaches give same result, one need to set c1 = 0.

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# Design and Development of an Autonomous Car using Object Detection with YOLOv4

By Rishabh Chopda, Saket Pradhan & Anuj Goenka

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*GJCST-A Classification:* *LCC Code: QA76.9.C65*

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# Design and Development of an Autonomous Car using Object Detection with YOLOv4

Rishabh Chopda [α], Saket Pradhan [σ] & Anuj Goenka [ρ]

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*Keywords: autonomous, self-driving, computer vision, YOLO, object detection, embedded hardware.*

## I. Introduction

A 'Self-Driving Car' is one that is able to sense its immediate surroundings and operate independently without human intervention. The main motivation behind the topic at hand is the expeditious progress of applied Artificial Intelligence and the foreseeable significance of autonomous driving ventures in the future of humanity, from independent mobility for non-drivers to cheap transportation services to low-income individuals. The emergence of driverless cars and their amalgamation with electric cars promises to help minimize road fatalities, air and small-particle pollution, being able to better manage parking spaces, and free people from the mundane and monotonous task of having to sit behind the wheel. Autonomous navigation holds quite a lot of promise as it offers a range of applications going far beyond a car driven autonomously. The main effort here is to keep the humans out of the vehicle control loop and to relieve them from the task of driving. The prime requisite of self-driving vehicles are the visual sensors (for acquiring traffic insight of vehicle surroundings), microprocessors or computers (for processing the sensor information and transmitting vehicle control instructions) and actuators (to receive said instructions and be responsible for the longitudinal and lateral control of the car) [1-4]. Autonomous vehicles are also expected to be manoeuvred in many of the most complex human planned endeavours, such as asteroid mining [5]. The meteoric rise of AI along with deep learning (DL) methods and frameworks, have made possible the development of such autonomous vehicles by many venture companies at the same time.

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## II. Software Development

In this section we elucidate the entire software development process which includes data collection and labelling, model training and model deployment.

*a) Data Collection & Labelling*

Around 2,000 images were collected for two types of coloured cones, namely: Orange and Blue. The cones were made from craft paper and were 4.5 centimetres tall with a base diameter of 3cm. The pictures included the cones laid out as track, single colour cones, multiple same-coloured cones and a mix of the two cones. A total of 16,382 cones were observed in the collected images with LabelImg being later used to label these cones from the images. 'LabelImg' is a graphical image annotation tool [6]. It is written in Python and uses Qt for its graphical interface. The LabelImg tool was used to label the photographed images in the YOLO format by drawing bounding boxes around the cones and naming each cone with their respective class i.e., colour (orange or blue). After labelling via LabelImg, a common class file was created to all images which contained the two classes "Orange" and "Blue". Another file was created unique to each image which contained the coordinates of each cone present in that image. For example, 1 0.490809 0.647894 0.235628 0.342580 is an entry from the class file created where the first parameter determines the class of the cones, the second and third parameters determine the midpoint of the bounding box while the fourth and fifth parameters determine the height and width of the bounding box. For the randomization

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and renaming of the images, a software tool called 'Rename Expert' was used. It randomized the images and then named them from 0-1681. Data augmentation was used to increase the amount of data by adding slightly modified copies of already existing data. It involves injecting some noise, rotation and flipping of the images to increase the number of images used for training. It usually helps in preventing overfitting the model and acts as a regularizer [7].

*b) Model Training*

YOLOv4 Tiny, a version of YOLOv4 developed for edge and lower-power devices, is a real-time object detection algorithm capable of detecting and providing bounding boxes for many different objects in a single image [8-11]. The model achieves this by dividing an image into regions and then predicting bounding boxes in addition to the probabilities for each region. Relative to inference speed, YOLOv4 outperforms other object detection models by a significant margin. We needed a model that prioritizes real-time detection and conducts the training on a single GPU as well. 'Darknet' is a framework like the Tensor Flow, PyTorch and Keras that proved to be apt for the task at hand. While Darknet is not as intuitive to use, it is immensely flexible, and it advances state-of-the-art object detection results. We train the model on darknet and then later convert it to Tensor Flow for ease in usability. This model can be tested on a physical model or on virtual simulators [12-15].In terms of training the model, the labelled dataset was segregated into training and validation datasets and was uploaded on cloud VM. After that, the darknet was cloned and built on which the model was trained. The parameters were configured periodically to achieve the best weights. It was important that we convert our darknet framework into Tensor Flow because only then could we make use of the Tensor Flow lite model which is optimized for embedded devices such as Jetson Nano to make the inference at the edge.

*c) Deployment*

Deployment includes reading the coordinate text data generated from the YOlO4 model into a NumPy framework and labelling the coordinate points according to the two classes, blue and orange. This is done by iterating through the text data line by line, and appending the required point objects into a python array, and finally converting the array into a NumPy format. Matplotlib is used to visualize the set of data points from the camera's perspective, on a 10 x 10 cm2 adjusted screen. Using the Scikit-Learn Library, a Linear Regression model is trained using the NumPy data. Two different models are to be trained; one for the blue set of cones, and one for the orange. Using the 'Linear Regression()' predefined method in the Scikit-Learn library, we could easily create a simple regression model without having to build the entire code for the model ourselves. The data is zipped and iterated through using a for loop. The output generated is explicitly converted into a list format. Two lines are created that pass through the orange cones and the blue cones. Again, a graph is plotted of Matplotlib for visual aid of the lines. Next, the equations of the previously formed lines are derived using simple geometric calculations. Straight line equations of the type: $ax + by + c = 0$ are obtained for both blue and orange lines. Next, the point of intersection of the two lines is calculated using the formula of point of intersection. The offset of this line is calculated from the centre of the screen and the x-coordinate of each point is subtracted by the corresponding point on the centre of the screen. This value is the mean deviation and will be used further to calculate the angle by which servo attached on the assembly is to be turned. Fig. 1 shows the outcome of the entire video capture and path mapping process.

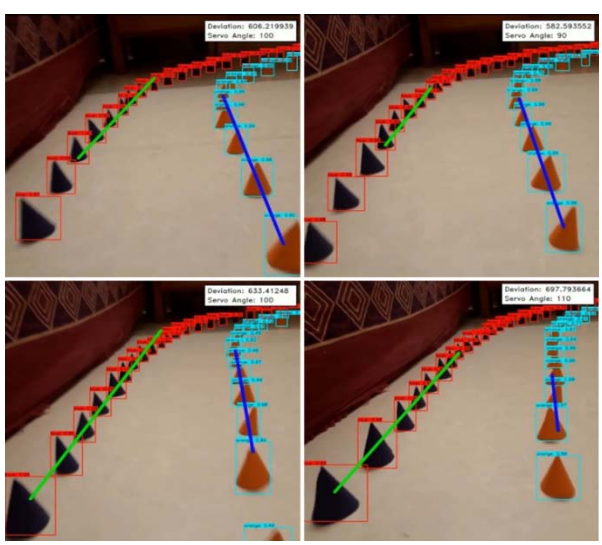

*Fig. 1:* Video Capture and Path Mapping Process

## III. Hardware Design

Before The car was designed and built with the proper placement and positioning of electronic components, such as the camera, in mind. It consists of three main parts, the steering assembly, the spur gear gearbox and the wheels. The steering system has a rack and pinion type design, chosen for its simple assembly and for providing easier and more compact control over the car. A 3-sided gear box ensures the effortless placement and positioning of the axles and larger gears. Given the opposing forces caused by the axles and front chassis, it also stays strong and sturdy. Spur gears are used in the gear box as they have high power transmission efficiencies (95% to 99%) and are simple to design and install. The wheels are designed and entirely 3D printed to have built-in suspension providing additional steering stability. Because the wheels must be flexible, TPU (Thermoplastic Polyurethane) is used to produce them. All other 3D printed components were produced using PLA (Polylactic acid) as it's easy to use, has a remarkably low printing temperature compared to other thermoplastics and produces better surface details and sharper features. A list of all materials is given below:

*List of Materials:* All components required for the prototype, including sensors, actuators, power supply, and hardware, are listed here. Fig. 2 and Fig. 3 show all the 3D printed parts and their assembly in Soild Works Simscape respectively.

- 3D Printed Parts
- 608zz Bearings (4x)
- Nvidia Jetson Nano
- 1200KV Brushless DC Motor
- 20A ESC (Electronic Speed Controller)
- 5000mAh Power Bank
- 11.1V - 2200mAH (Lithium Polymer) LiPo Recharge-able Battery
- PCA9685 16 Channel Servo Driver
- TowerPro SG90 180° Rotation Servo Motor
- Logitech C615 HD Webcam

*Fig. 2:* 3D Printed Parts

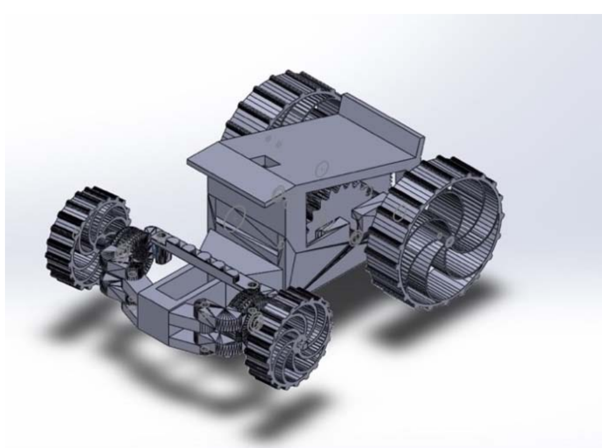

*Fig. 3:* Car Assembly on Solid Works Simscape

## IV. Functionality

A Nvidia Jetson Nano single-board computer (SBC) serves as both the brain and the communication node in the prototype control system. This SBC receives data from the camera, analyses them, and integrates them into the navigation system to determine the steering angle. A 11.1V - 2200mAH LiPo battery is used solely to power the vehicle's propulsion system, that is, the 1200KV Brushless DC Motor with a 20A ESC. A 180° rotation servo motor with a torque of 1.2KgCm, controlled by the PCA9685 16 Channel Servo Driver, is used to steer the car. Fig. 4 and Fig. 5 show a flowchart of the instruction feedback loop and a schematic diagram of the hardware connections respectively. Fig. 6shows the entire assembled car.

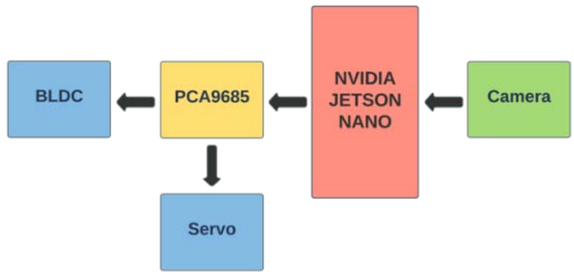


*Fig. 4:* Flowchart of the Instruction Feedback Loop

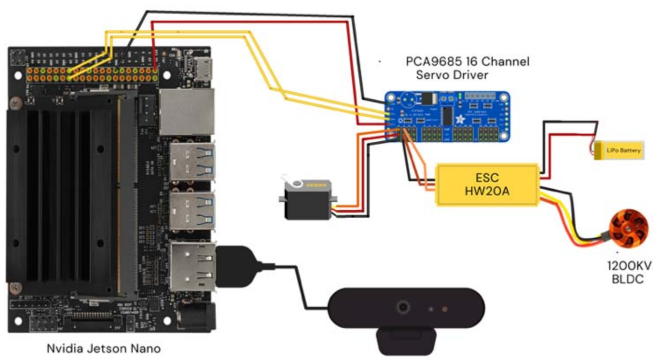


*Fig. 5:* Circuit Diagram

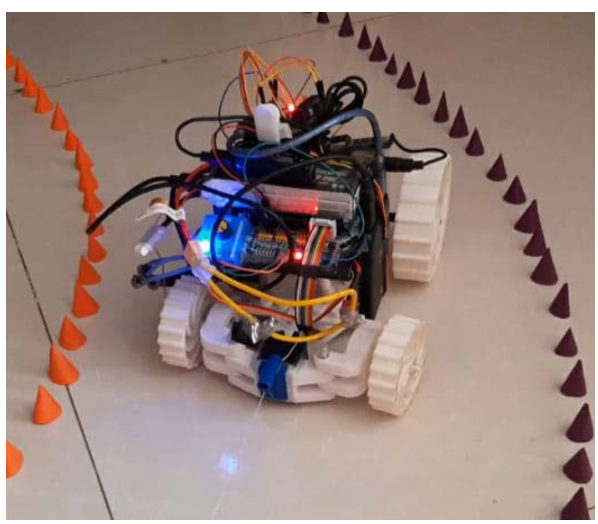

*Fig. 6:* Assembled Car

## V. Conclusion

Through this paper, we present an approach for designing and building a model self-driving car based on the concept of Behavioural Cloning. This approach being an end-to-end one does not require any of the conventional tasks of feature extraction or connection of various modules, which are often monotonous, manual in nature and necessary for efficient working. Our model car is tried and tested in real life against various standard models such as DenseNet-201, Resnet-50, and VGG19 for the comparison and performance. The final proposed model is a convolution-based, ten 2D-Convolutional Layers, one Flat Layer and four Dense Layers model. When compared with other Deep Learning based models, our model seems to have outperformed all of the aforementioned standard models by a substantial margin. The work presented through this paper can be realized to build vehicles capable of autonomous steering and driving. Additional training data of real-world obstacles with different track situations and conditions may be required to increase the agility and robustness of the system.

## VI. Future Scope

Through this project, we aimed to provide proof of concept for self-driving cars that can solely rely on vision-based object detection techniques for navigation, rather than the conventional feature extraction-based lane detection techniques. Results obtained on our model car made it clear that our approach towards object detection as a means of steering has either outclassed or is at-par with humans in the parameters being tested for. Reinforcement learning methods can be introduced in addition to this method to better performance. This method can be used as a prototype for future citywide self-driving cars projects. It can also be used exclusively, or in addition to conventional lane detection, to further improve on accuracy of self-driving cars. Via these techniques, automobiles might truly serve as end-to-end personal transportation devices and may give rise to an entire ecosystem of car-pooling or car sharing services as well as numerous start-ups thereby making personal transport cheaper, faster and safer. However, when implementing in the real world, many more parameters might be introduced which may increase the complexity of such a system while affecting the performance of the car.

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Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

## Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

**Changes in Authorship**

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

**Copyright**

During submission of the manuscript, the author is confirming an exclusive license agreement with Global Journals which gives Global Journals the authority to reproduce, reuse, and republish authors' research. We also believe in flexible copyright terms where copyright may remain with authors/employers/institutions as well. Contact your editor after acceptance to choose your copyright policy. You may follow this form for copyright transfers.

**Appealing Decisions**

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

**Acknowledgments**

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

**Declaration of funding sources**

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

## Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

***Manuscript Style Instruction (Optional)***

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

***Structure and Format of Manuscript***

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

## Format Structure

***It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.***

All manuscripts submitted to Global Journals should include:

**Title**

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

**Author details**

The full postal address of any related author(s) must be specified.

**Abstract**

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

**Keywords**

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

**Numerical Methods**

Numerical methods used should be transparent and, where appropriate, supported by references.

**Abbreviations**

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

**Formulas and equations**

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

**Tables, Figures, and Figure Legends**

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

**Figures**

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

## Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

## Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

***1. Choosing the topic:*** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

***2. Think like evaluators:*** If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

***3. Ask your guides:*** If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

***4. Use of computer is recommended:*** As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

***5. Use the internet for help:*** An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

***6. Bookmarks are useful:*** When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

***7. Revise what you wrote:*** When you write anything, always read it, summarize it, and then finalize it.

***8. Make every effort:*** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

***9. Produce good diagrams of your own:*** Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

***10.Use proper verb tense:*** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

***11. Pick a good study spot:*** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

***12. Know what you know:*** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

***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.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- 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.
- 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?
- 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.

## Criterion for Grading a Research Paper (Compilation)
## by Global Journals Inc. (US)

**Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).**

| 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<br><br>Above 200 words | No specific data with ambiguous information<br><br>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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