

**ARTIFICIAL INTELLIGENCE  
ITE2010**

Slot : G1+TG1

**SQL INJECTION PREVENTION SYSTEM USING MACHINE  
LEARNING ALGORITHMS**

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# SQL Injection Prevention System using Machine Learning Algorithms<sup>1,2,3</sup>

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## Abstract

Existing Web system flaws jeopardize information systems' ability to operate normally. SQL injection is by far the most prevalent Web system flaw. In this article, you'll find information on how to secure Web applications from SQL injection attacks. To increase the security of Web applications, a defensive mechanism has been designed to defend Web resources against SQL injection. PHP, JavaScript, and regular expressions are utilized to implement this programme. As a result, a application for protecting Web applications against SQL injection vulnerabilities has been developed. The programme allows a user to utilize SQL to secure his own Web application from an attack.

**Keywords:** SQL Injection, Web App Security, Detection Strategies, Scanning Method, Prevention of SQL Injection Attacks, Input Validation, Parameterized Queries, Escaping, Stored Procedures, Mitigation using Log-In Gateway System

## I. Introduction

Attackers frequently use SQL injection attacks to gain unauthorized access to systems. This programme was created to prevent SQL injection attacks from gaining unauthorized access to the system. This is accomplished by using a signature-based authentication mechanism to check validity and adding a unique value. These days, SQL injection is a critical security concern that allows an attacker to get access to an online system or application by exploiting certain vulnerabilities. This approach takes use of a variety of web application aspects, such as conveying traveling form data parameters and efficiently integrating amino acid codes that are aligned in it. To put it another way, this software project proposes a mechanism for analyzing and detecting malicious code in order to identify and prevent an attack. It employs a distinct signature-based scanning technique that employs a different divide-and-conquer strategy to detect assaults based on multiple time/space factors. Based on its effective attack detection methodologies, this unique technology has proven successful in blocking numerous SQL injection attacks.

## II. Background Knowledge

Gradient Boosting works by adding predictors to an ensemble in a progressive manner, each one correcting the one before it. Unlike AdaBoost, however, this strategy aims to adapt the new predictor to the residual errors created by the prior predictor rather than modifying the instance weights at each iteration. Boosting algorithms work on the idea of first building a model on the training dataset, then building a second model to correct the faults in the first model. Gradient Boosting Regressor is used when the goal column is continuous, while Gradient Boosting Classifier is used when it is a classification problem.

The "Loss function" is the sole difference between the two. The goal here is to use gradient descent to reduce this loss function by adding weak learners. The first stage in gradient boosting is to create a base model that predicts the observations from the training dataset. For the sake of simplicity, we take the target column's average and assume it to be the anticipated value. This step can be stated mathematically as :

$$F_0(x) = \arg \min_{\gamma} \sum_{i=1}^n L(y_i, \gamma).$$

**L** denotes our loss function, **gamma (y)** denotes our predicted value, and **arg min** denotes that we must find a forecasted value/gamma for which the loss function is least. Our loss function will be (because the target column is continuous) :

$$L = \frac{1}{n} \sum_{i=0}^n (y_i - \gamma_i)^2$$

In this case, **y<sub>i</sub>** is the observed value. And the projected value is **gamma(y)**. Now we need to find a gamma value that is as low as possible while still minimizing this loss function – thus we shall use the below function:

$$\frac{dL}{d\gamma} = \frac{2}{2} \left( \sum_{i=0}^n (y_i - \gamma_i) \right) = - \sum_{i=0}^n (y_i - \gamma_i)$$

Remember that **y<sub>i</sub>** represents our observed value and **y<sub>i</sub>** represents our expected value. The pseudo residuals, which are (observed value – anticipated value), are then calculated – via the following formula :

$$r_{im} = - \left[ \frac{\partial L(y_i, F(x_i))}{\partial F(x_i)} \right]_{F(x)=F_{m-1}(x)} \quad \text{for } i = 1, \dots, n.$$

F(x<sub>i</sub>) is the prior model, and m is the number of DT produced. Now we need to determine the output values for each leaf of our decision tree. That means there's a chance one leaf will acquire more than one residual, therefore we'll need to figure out the total production of all the leaves. To obtain the output, simply take the average of all the numbers in a leaf, regardless of whether there is only one value or more than one – mathematically :

$$\gamma_m = \arg \min_{\gamma} \sum_{i=1}^n L(y_i, F_{m-1}(x_i) + \gamma h_m(x_i)).$$

Here, **h<sub>m</sub>(x<sub>i</sub>)** is the residual-based DT, and m is the number of DT. When m=1, we are referring to the first DT, and when it is "**M**" we are referring to the last DT. The leaf's output value is the gamma value that minimizes the Loss function. The left-hand side "**Gamma**" represents the output value of a certain leaf. Finally, we must revise the prior model's predictions :

$$F_m(x) = F_{m-1}(x) + \nu_m h_m(x)$$

where  $m$  is the number of decision trees created.

Now this was all about Gradient Boosting , let us go towards Gradient Boosting Classifier. When the target column is binary, a gradient boosting classifier is applied. All of the procedures described in the Gradient boosting regressor are applied here; the only difference is that the loss function is changed.

When the target column was continuous, we utilized Mean squared error as our loss function; this time, we would use log-likelihood. The classification problem's loss function is shown below.

$$L = - \sum_{i=1}^n y_i \log(p) + (1 - p) \log(1 - p)$$

Let us first turn this loss function into a log function (odds)

$$\begin{aligned} L &= - \left[ \sum_{i=1}^n y_i \log(p) + (1 - y_i) \log(1 - p) \right] \\ &= -y * \log(p) - (1 - y) * \log(1 - p) \\ &= -y * \log(p) - \log(1 - p) + y * \log(1 - p) \\ &= y * [\log(p) - \log(1 - p)] - \log(1 - p) \\ &= -y * \left[ \frac{\log(p)}{\log(1 - p)} \right] - \log(1 - p) \\ &= -y * \log\left(\frac{p}{1 - p}\right) - \log(1 - p) \\ &= -y * \log(\text{odds}) - \log(1 - p) \end{aligned}$$

$$\begin{aligned} \text{Now, } \log(1 - p) &= \log\left(1 - \frac{e^{\log(\text{odds})}}{1 + e^{\log(\text{odds})}}\right) \\ &= \log\left(\frac{1 + e^{\log(\text{odds})}}{1 + e^{\log(\text{odds})}} - \frac{e^{\log(\text{odds})}}{1 + e^{\log(\text{odds})}}\right) = \log\left(\frac{1}{1 + e^{\log(\text{odds})}}\right) \\ &= \log(1) - \log(1 + e^{\log(\text{odds})}) \\ &= 0 - \log(1 + e^{\log(\text{odds})}) \end{aligned}$$

$$\text{Hence, } -y * \log(\text{odds}) - \left(-\log(1 + e^{\log(\text{odds})})\right)$$

$$L = -y * \log(\text{odds}) + \log(1 + e^{\log(\text{odds})})$$

Further , taking the derivative –

$$\frac{dL}{d[\log(\text{odds})]} = -y + \frac{e^{\log(\text{odds})}}{1 + e^{\log(\text{odds})}}$$

We know  $\frac{e^{\log(\text{odds})}}{1 + e^{\log(\text{odds})}} = p$ , hence we can substitute  $p$

$$\frac{dL}{d[\log(\text{odds})]} = -y + p$$

, here  $y$  is the observed values

Now ,

$$\frac{dL}{d[\log(\text{odds})]} = -y + p$$

$$\frac{dL}{d[\log(\text{odds})]} = -(-y + p) = (y - p) = (\text{observed} - \text{predicted})$$

Now that we have our first decision tree, we need to get the final output of the leaves because a leaf may have more than one residual, thus we need to compute the final output value –

$$\gamma = \frac{\sum_{i=1}^n \text{Residual}_i}{\sum_{i=1}^n [\text{Previous probability}_i \times (1 - \text{Previous probability}_i)]}$$

Finally, we are ready to generate fresh predictions by combining our base model with the residuals tree we created.

## II. Literature Survey

Sr. No	Title (Year)	Authors	Algorithm / Method used	About
1.	SQL Injection Attacks Prevention System Technology	Fairoz Q Kareem Siddeeq Yousif Ameen  Awder Ahmed Sulaimani Azar Abid Salih	Nikto, SQLMAP SQL injection with SVM SQL injection with neural network SQLA, DIAVA, SQL injection	1. All content management systems were not susceptible to assaults via SQLi but provided alerts on other potential flaws. 2. Launch new SQL assaults with comparable assault patterns and payloads with the current one 3. Its advantages are the accuracy of neural networks for detecting SQL injection is superior to the relevant machine learning algorithms. 4. DIAVA not only conducts advanced WAFs for SQLA detection from the point of view of precision and recall but also allows the assessment of leaked data causing SQL injection in real-time
2.	A Classification of SQL Injection Attacks and Countermeasures	William G.J. Halfond, Jeremy Viegas, and Alessandro Orso	Black Box Testing. Static Code Checkers AMNESIA (Combined Static and Dynamic Analysis). Taint Based Approaches New Query Development Paradigms Intrusion Detection Systems. Proxy Filters. Instruction Set Randomization	Well suited and efficient for large code segments Code access is not required.
3	SQL Injection Attacks: Techniques and Protection Mechanisms	Nikita Patel, Fahim Mohammed, Santosh Soni	Taking User Input from Predefined Choices. Bind Variables. Mechanism Parameterized Statements.	The attacker cannot insert custom queries or any type of harmful script which can disturb the integrity of the database. helps in improving web-

			Input Validation.	application performance. Every passed string parameter ought to be validated. Many web applications use hidden fields and other techniques, which also must be validated. If a bind variable is not being used, special database characters must be removed or escaped.
4	PROTECTION OF WEB APPLICATION AGAINST SQL INJECTION ATTACK	Manisha A. Bhagat, Prof. Vanita Mane	JDBC-Checker. ADMIRE. SQL-PROB. WAVES. SQLRand. SQL DOM. VIPER. CANDID.	SQL Injection attack is one of the most popular attacks used in system hacking or cracking. Web applications are consisting of web forms, web server and backend. These applications are vulnerable due to attacks and scripts as the number of web application users are increasing. When attacker gains control over web application maximum damage is caused.
5	SQL Injection Attack Detection and Prevention Techniques Using Machine Learning	Ines Jemal, Omar Cheikhrouhou, Habib Hamam, Adel Mahfoudhi.	Query-model based. Obfuscation based. Monitoring and Auditing Based. Entropy Based. Ontology Based.	The process begins by analyzing the source code used in the web application and vulnerable in execution, then optimizing these vulnerable queries. The optimization engine generates a set of valid execution in accordance with the heuristic rules. Finally, the hotspot (vulnerable part of code) is replaced by the web application code with its optimized query. The authors in proposed an automated testing approach, namely $\mu 4SQLi$ . $\mu 4SQLi$ can produce effective inputs that lead to executable and malicious SQL queries. The idea is to produce inputs that bypass web application firewalls. The goal of this tool is to detect potential SQL vulnerabilities in a given web application.
6	A novel technique to prevent SQL injection and cross-site scripting	Oluwakemi Christiana Abikoye, Abdullahi Abubakar, Ahmed	Formation of SQL injection string patterns.	Every form of attacks has certain characters and keywords that hackers do

	attacks using Knuth-Morris-Pratt string match algorithm	Haruna Dokoro, Oluwatobi Noah Akande & Aderonke Anthonia Kayode	Designing parse tree for the various forms of attacks.	manipulate to perpetuate their attacks these characters and keywords are used to form malicious codes that are used to carry out the various forms of attacks. Identifying these injection codes will help in coming up with how to detect and prevent these attacks. Parse tree was used to represent the syntactic pattern of the various forms of SQL-Injection and Cross Site Scripting attacks
7	An Efficient Technique for Detection and Prevention of SQL Injection Attack using ASCII Based String Matching	Indrani Balasundarama, E. Ramarajb	Proposed SQLIA - Protector Mechanism An Authentication Scheme using Hybrid Encryption	Because of high level security the proposed scheme consists of three filtration phases with static and dynamic level. First level phase is Malicious Text Detector, second level phase is Constraint Identifier, third level phase is Static Query Analysis and the Fourth level Phase is Textbased Key Generator.
8	TransSQL: A Translation and Validation-based Solution for SQL-Injection Attacks	Kai Xiang Zhang, Chia-Jun lin et al	a solution in form of TransSQL to detect malicious SQL queries	It is a server side solution, so modification or update is not required in the legacy web application. Automatic and platform independent deployment and installation. No need to learn LDAP, thus user's training cost is null.
9	An Approach for SQL Injection Vulnerability Detection- AMNeSIA 2009	M. Junjin	Static analysis Runtime analysis	Automatically generate SQL query on the basis of possible legitimate queries by analyzing web application code. scans all dynamically generated SQL queries and checks their compliance to the statically generated models.



10	A SQL Injection Detection Method Based on Adaptive Deep Forest (2019)	Qi Li, Weishi Li, Junfeng Wang, Mingyu Cheng	<ol style="list-style-type: none"> <li>1 An adaptive deep forest-based method is incorporated to detect the complex SQL injection attacks.</li> <li>2 An algorithm, AdaBoost, algorithm is used. It is based on deep forest model which utilizes error rate to update the weights of features on each layer.</li> </ol>	<ol style="list-style-type: none"> <li>1 Using this methodology, the existing problem of deterioration in efficiency of features of deep forests as the number of layers increases is tackled completely.</li> <li>2 The structure of the tree model can be modified automatically.</li> <li>3 Multi-dimensional fine-grained features can be dealt with properly to avoid the problem of over-fitting.</li> <li>4 The methodology used experimentally demonstrates not only better detection accuracy and low computational cost but also high flexibility and high robustness.</li> </ol>
11	SQL Injection Detection for Web Applications Based on Elastic-Pooling CNN (2019)	Xin Xie, Chunhui Ren, Yusheng Fu, Jie Xu, Jinhong Guo	<ol style="list-style-type: none"> <li>1. Convolutional Neural Network (CNN) is a powerful deep feedforward neural network which can replicate the formation mechanism employed in organisms for vision cognition.</li> <li>2. CNN is applied to the detection of SQL injection in Web applications, and detection of SQL injection attacks from very vast web logs is done.</li> </ol>	<ol style="list-style-type: none"> <li>1. Identification of new and harmful attacks can be successfully done with the help of irregular matching characteristics and is thus, much more difficult to bypass.</li> <li>2. Since the vocabulary is usually small, the training difficulty and cost are reduced considerably.</li> <li>3. This method can also be beneficially used as an auxiliary method of existing traditional SQL detection methods.</li> </ol>

			<ol style="list-style-type: none"> <li>This method automatically extracts the hidden common features of SQL injection and is thus able to identify new attacks, bypassing the regular SQL injection.</li> </ol>	
12	JS-SAN: defense mechanism for HTML5- based web applications against javascript code injection vulnerabilities (2016)	Shashank Gupta, B.B. Gupta	<ol style="list-style-type: none"> <li>injection and clustering-based sanitization framework, i.e. JS- SAN (JavaScript SANitizer) for the mitigation of JS codeinjection vulnerabilities.</li> <li>It generates an attack vector template by performing the clustering on the extracted JS attack vector payloads corresponding to their level of similarity. As a result, it then sanitizes the extractedJS attack vector template by an automated technique of placement of sanitizers in the source code of generated templates of web applications.</li> </ol>	<ol style="list-style-type: none"> <li>The proposed framework validates its novelty by producing a less rate of false negatives and tolerable runtime overhead as compared to existing sanitization- based approaches.</li> </ol>
13	Detection and Prevention of Code Injection Attacks on HTML5- Based Apps (2015)	Xi Xiao; Ruibo Yan; Runguo Ye; Qing Li; Sancheng Peng; Yong Jiang	<ol style="list-style-type: none"> <li>JavaScript code is encoded in a human-unreadable form. Then we use classification algorithms of machine learning to determine whether an app suffers from the code injection attack or not.</li> </ol>	<ol style="list-style-type: none"> <li>Precision of the proposed detection method reaches 95.3%.</li> <li>Compared to the other methods, new approach improves a lot in detection speed with the precision nearly unchanged.</li> <li>An improved access control model is</li> </ol>

				<p>proposed to mitigate the attack damage.</p> <p>4. Filters are adopted to remove JavaScript code from data to prevent the attacks.</p>
14	Detecting and Removing Web Application Vulnerabilities with Static Analysis and Data Mining (2016)	Ibéria Medeiros; Nuno Neves; Miguel Correia	<ol style="list-style-type: none"> <li>1. We combine taint analysis, which finds candidate vulnerabilities, with data mining, to predict the existence of false positives</li> <li>2. Automatic code correction by inserting fixes in the source code.</li> <li>3. The proposed approach was implemented in the WAP tool, and an experimental evaluation was performed with a large set of PHP applications.</li> </ol>	<ol style="list-style-type: none"> <li>1. It is an enhanced form of detection.</li> <li>2. This novel study brings together two approaches that have been considered orthogonal until now.</li> <li>3. It combines humans coding the knowledge about vulnerabilities (for taint analysis) and automatically obtaining that knowledge (with machine learning, for data mining).</li> </ol>

15	Study On SQL Injection Attacks: Mode, Detection And Prevention (2016)	Subhranil Som, Sapna Sinha ,Ritu Kataria	<ol style="list-style-type: none"> <li>1. The paper has dealt with the security on the ends by proposing the two systems for avoiding SQL Injection Attacks. Its two stages are: <ul style="list-style-type: none"> <li>a) Frontend Phase</li> <li>b) Backend</li> </ul> </li> <li>2. Initially at front end the Database is secured from any SQLIA. An additional section in client table is used to store the Final Hash Code, which is obtained during enrollment time of a client for the first time and is put into client table along with client name and secret key.</li> <li>3. In the backend phase, The framework notices on how SQLIA on Web applications by tokenization and encryption for detection and prevention.</li> </ol>	<ol style="list-style-type: none"> <li>1. This paper has demonstrated a strategy to change over SQL query into number of helpful tokens by applying tokenization and after that encoding all literals, fields, table and information on the query by AES-algorithm to avoid SQLIA.</li> <li>2. This methodology encourages quick and proficient getting to system with database and keeps away from memory necessities to store the actual query in storehouse.</li> <li>3. This methodology because of its low preparing overhead has minimal impact on execution even at higher burden conditions and does not require real changes to application code.</li> </ol>
16	Web based testing application security system using	Akbar Iskandar, Muhammad Resa Fahlepi Tuasamu ,	<ol style="list-style-type: none"> <li>1. This research uses semantic comparison method to detect SQL injection. Semantic comparisons are</li> </ol>	<ol style="list-style-type: none"> <li>1. The design and testing of the system on the registration form shows that if there is field that has not been filled or empty on the registration</li> </ol>

	semantic comparison method (2018)	Suryadi Syamsu , M Mansyur , Tri Listyorini , Sulfikar Sallu , S Supriyono, Kundharu Saddhono , Darmawan Napitupulu and Robbi Rahim	<p>performed by parsing each statement and comparing syntactic data structures. If the syntax structure of the two queries is equivalent, then the query induces equivalent semantic action on the database server.</p> <p>2. Research based on a use case of a registration and login form.</p>	<p>form then it shows a message notification that the field must be filled and after all the fields are filled, semantic comparison will compare the query in the system database. The password created by the user has been encrypted and the encrypted password will be decrypted using MD5 decrypter where the data is encrypted using an encryption key to be something that is difficult to read by someone.</p> <p>Therefore, every website or web application needs to apply the semantic comparison method and apply Message Digest 5 (MD5) algorithm which is widely used to prevent the occurrence of attacks from crackers who are trying to find a web vulnerability because most applications accessed via the internet have a login page which can be used to authenticate app users.</p> <p>The attacker intends to log in without using the correct username and correct password. But as if entering the correct username, where if the attacker uses injection like "hacker OR 1='1'" as username and suppose "something" is used as password, then the query will be like this: Select * from login where user = 'hacker' OR '1'='1' - 'and pass = 'something' When this query is run in the</p>
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				<p>database, it will always be considered correct and authentication will work.</p> <p>Based on the results and design of research, it can be concluded that using semantic comparison method can prevent dangerous Structured Query Language Injection Attack and can secure the account of web testing users by using MD5.</p>
17	SQL Injection (2013)	Stephanie Reetz, SOC Analyst	<ol style="list-style-type: none"> <li>1. This paper talks about various SQL injection vulnerability, attack scenarios, blind SQL Injection and mitigation.</li> </ol>	<ol style="list-style-type: none"> <li>1. The three main defense strategies against SQL injection are parameterized queries, stored procedures, and input validation. The first option is the use of parameterized queries. They require that all SQL code is first defined and then parameters are passed to the query. They are easier to write than dynamic queries and help prevent SQL injection by differentiating between the SQL code and the user-supplied data.</li> <li>2. The second defense strategy, comparable to the first, is the use of stored procedures which prevent SQL injection as long as they do not include any unsafe dynamic SQL generation.</li> <li>3. The third approach is to escape all user-supplied input before adding it to a query. When user supplied input is escaped, special characters are replaced with characters the database should not confuse with SQL code written by the developer. The specific functions used for escaping user supplied input vary by server-side scripting language.</li> </ol>

18	A Study on SQL Injection Techniques (2016)	Rubidha Devi.D, R.Venkatesan , Raghuraman.K	<ol style="list-style-type: none"> <li>1. Comprehensive coverage about topics like basics of SQL Injection, types, recent attacks as a case study.</li> <li>2. Tautology SQL injection – one of the code injection techniques is widely used as a data – driven attack as per the security related literature and causes severe damage to the organizational data banks.</li> </ol>	<ol style="list-style-type: none"> <li>1. SQL Injection through Tautologies used for bypassing authentication like -&gt; Select * from user det where uid='abcd' and pwd ='a' or '3'='3'</li> <li>2. SQL Injection through Union used for extracting Data like -&gt; Select * from userdet where uid='union select * from details -- and pwd='a';</li> <li>3. SQL Injection through Piggybacked Queries to extract different datasets like -&gt; SELECT Rno FROM St WHERE login = 'abc' AND pass = ''; DROP table St --'</li> <li>4. SQL Injection through Inference Determining used for database Schema like -&gt; SELECT name, email FROM members WHERE id=1; IF SYSTEM_USER='sa' SELECT 1/0 ELSE SELECT 5</li> <li>5. SQL Injection through Stored Procedure used for executing remote Commands like -&gt; SELECT Eid, Ename FROM Employee WHERE Ename LIKE '8' or '8' = '8'; EXEC master.dbo. xp_cmdshell 'dir' --'</li> </ol>
19	Using Parse Tree Validation to Prevent SQL Injection Attacks	Gregory T. Buehrer, Bruce W. Weide, and Paolo A. G. Sivilotti	1. A parse tree is a data structure for the parsed representation of a statement. Parsing a statement requires the grammar of the statement's language. By parsing two statements and comparing	1. Most web applications employ a middleware technology designed to request information from a relational database in SQL. SQL injection is a common technique hackers employ to attack these web-based applications. These attacks

20	Detection of SQL Injection attacks: A Machine Learning Approach	Musaab Hasan, Zayed Balbahaith, Mohammed Tarique	This paper talks about various SQL injection vulnerability, attack scenarios, Support Vector Machine(SVM), Naïve Bayes, RBC control mechanism and SQL detection.	It is easy and fast to predict the class of the test data set. It also performs well in multi-class prediction. When assumption of independence holds, a Naive Bayes classifier performs better compare to other models like logistic regression and you needless training data.
21	Applied Machine Learning Predictive Analytics to SQL Injection Attack Detection and Prevention	T.P.Latchoumi, Manoj Sahit Reddy, K.Balamurugan	The proposed detection model may report vulnerabilities in web applications.	Continuous web security against OWASP  Give developers a confidence boost in their own code.
22	Applied Machine Learning Predictive Analytics to SQL Injection Attack Detection and Prevention	Solomon Uwagbole, William J Buchanan, L.Fan	Support vector machine learning, proxy filters	SVM works relatively well when there is a clear margin of separation between classes. SVM is more effective in high dimensional spaces. SVM is effective in cases where the number of dimensions is greater than the number of samples. SVM is relatively memory efficient.
23	An Improved SQL Injection Attack Detection Model Using Machine Learning Techniques	Yazeed Abdulmalik	Sql static and dynamic Analysis.	It identifies vulnerabilities in a runtime environment.  Automated tools provide flexibility on what to scan for.  It allows for analysis of applications in which you do not have access to the actual code.
24	SQL Injection Detection Using Machine Learning 2019	Sonali Mishra	SQL Injection (Union, Blind. Error), Naïve Bayes, Ensemble Learning, Bagging and Boosting.	Performance: An ensemble can make better predictions and achieve better performance than any single contributing model. Robustness: An ensemble reduces the spread or dispersion of the predictions and model performance.



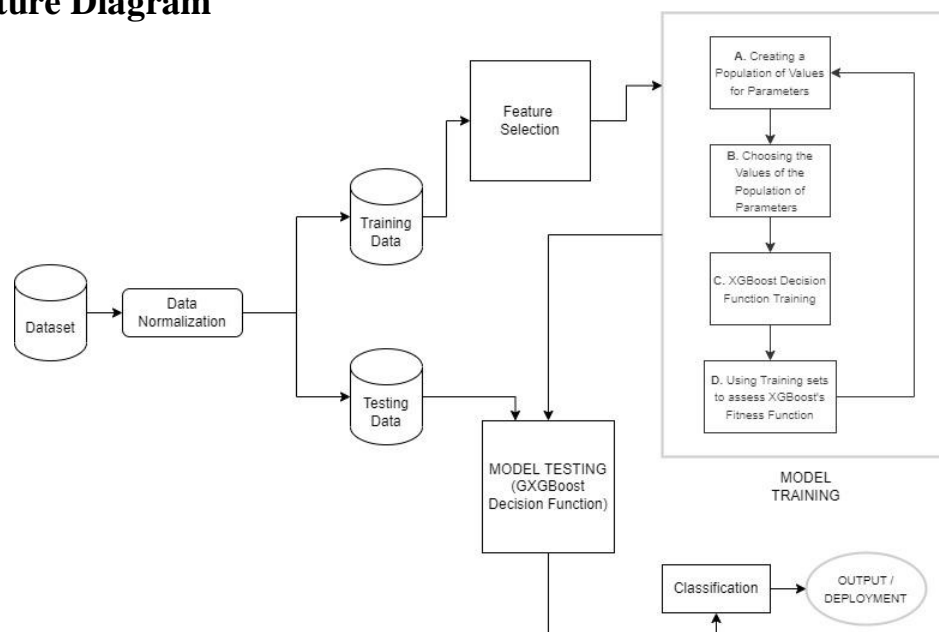
25	Detection of SQL Injection using Machine Learning: A Survey- Nov2019	Tareek Pattewar, Hitesh Patil, Harshada Patil , Neha Patil , Muskan Taneja , Tushar Wadile	Naïve bayes, bagging and boosting, gradient boosting  Encryption alog's: MD5 algorithm, AEs algorithm	MD5 Algorithms are useful because it is easier to compare and store these smaller hashes than store a large variable length text. ...  Moreover, it is very easy to generate a message digest of the original message using this algorithm.
26	SQL Injection Detection using Machine Learning	Anamika Joshi and Geetha V.	Using Naïve Bayes ML algorithm.	It is easy and fast to predict the class of the test data set. It also performs well in multi-class prediction. When assumption of independence holds, a Naive Bayes classifier performs better compare to other models like logistic regression and you need less training data.
27	SCAMM: Detection and Prevention of SQL Injection Attacks	Auninda Alam, Marjan Tahreen, Md Moin Alam, Shahnewaz Ali Mohammad, Shohag Rana	They use machine learning algorithms in order to train their model so that it may detect any known kind of SQL injection attempts and even identify new approaches of attacks from its previous training	This model can be used to supplement the protective measures of any kind of website. It can be used to protect the database of various web applications. It is expected to serve as an added layer of protection to database servers of any kind of system
28	Prevention Of Sql Injection Attack Using Unsupervised Machine Learning Approach	M.N.Kavith a, V. Vennila, G.Padmapriya, A. Rajiv Kannan	Sql Injections Using Machine Learning Serves As prevention Mechanism To The Utilization Of Any Database In The Server Side. In This Methodology, A Segment Is Built Up That Lives In The Server Side[12]. The System Checks For The Sql Injection Attack Patterns That Are Affixed With The Values Passed To The Application Server Prior To The Processing Of The Query Made By The Client	. Two Levels Of Security Are Defined In This System: In The First Level The Patterns Produced By The Cfg Rules And Relating These Values With The Pattern Produced By The Rules That Are Set For Sql Attacks
29	Web Application Attacks Detection Using Machine Learning Techniques	Gustavo Betarte , Rodrigo Mart'inez and Alvaro Pardo	Here they are using some ML techniques for Web Application Attacks Detection.	Most web applications employa middleware technology designed to request information from a relational database in SQL.

30	SQL-IDS: Evaluation of SQLi Attack Detection and Classification Based on Machine Learning Techniques	Naghmeh Moradpoor Sheykhkanlo o	Here they have proposed a neural network-based model for detection and classification of SQLi attacks.	The NN model deals with the URL addresses that have already been classified into either benign or malicious. It also has knowledge about the type of SQLi attack for malicious URLs. The NN model receives this information from the URL classifier and takes it into account for three phases of: training, validating and testing with distribution rates of 70%, 15%.
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### III. Proposed Methodology

SQL Injections are one of the most used web attack vectors, which is used with the goal of retrieving sensitive data from organizations. Stolen Credit Cards or password files happens through SQL injection vulnerabilities. But now, we have ways to protect various websites from SQL Injection attacks. SQL Injection is a technique that is used by the attackers in which they insert SQL query into input fields which will then be processed by the underlying SQL database. These weaknesses will then be abused when entry forms allow the user generated SQL statements to query the database directly. There are various threats that an individual or an organization may suffer due to such attacks. Threats like extraction of private data such as credit card information, passport information, hospital records, etc. and sometimes enumeration of the authentication user details, allowing these logins to be used on other website along with a corrupted database as well as execution of OS commands, deleted/inserted data and destroyed operations for the entire website that might lead to system compromise. So, there is a need for developing a technique that will be able to protect the sensitive data of an individual or an organization and prevent such attacks in the future.

#### Architecture Diagram



In this programme, we have extensively used Regular Expressions. A regular expression (also known as a rational expression) is a set of characters that create a search pattern, mostly for pattern matching with strings or string matching, i.e., "find and replace" operations. It provides a robust and flexible pattern match that can assist us in implementing sophisticated database search tools. When matching regular expression patterns, the REGEXP operator is utilized. The word RLIKE is a synonym. It also includes a set of metacharacters that provide you additional freedom and control during pattern matching. As an escape character, the backslash is employed. If double backslashes are used, it is only considered in the pattern match. Above all, it is unaffected by case. We have another term – whose concept is inculcated with the usage of REGEXP – namely , Tokenization. Tokenization in Python is the process of breaking down a huge body of text into smaller lines, words, or even inventing new terms for a language other than English. We are using REGEXP for tokenizing each SQLI (SQL Injection) attack. Later the token count values will be considered for generation of a dataset. Apart from generating our own dataset , we shall also opt for importing / obtaining dataset from other website(s) – like Kaggle , Data.Gov , Datahub.io , UCI Machine Learning Repository , etc. Now , if the dataset is an imported one , we will have to tokenize the raw SQL (from the dataset). But SQL tokens are nothing but garbage for the Machine Learning Model – thus , we have to set real features for the aforementioned. After listing of feature vectors (feature detection done here) and Encoding categorical features , the dataset shall be splitted into Training and Testing dataset (the proportion is kept as 80% and 20% respectively – as training dataset has to be atleast  $\frac{3}{4}$ <sup>th</sup> (75%) the whole dataset OR the testing dataset has to be at most  $\frac{1}{4}$ <sup>th</sup> (25%) of the whole dataset. This can be done using train\_test\_split function of Scikit-learn Library (under model selection). Here , the algorithm taken is Gradient Boosting Classifier. The model training Gradient Boosting Classifier model consists of 4 parts. After extensive training , we shall proceed for testing the model on the testing dataset – for which , the dataset has to be tokenized. Afterwards , it shall denote whether the dataset-code is containing SQL Injection codes OR is it a normal / acceptable code – Hence , showing the classification result(s).

## IV. Results

```
sqli      5921
plain     3694
Name: type, dtype: int64
Gradient Boosting Tree Accuracy: 1.000000
----- Result: -----
Machine Check Count: 13780
Sql-injection: 9731
Plain-text: 4049
--- 28636.5072966 seconds
```

The dataset taken has 13780 codes , of which the Gradient Boost Classifier could detect 9731 codes which are SQLI codes , and could detect 4049 normal / valid codes – without anomalies.

## V. Conclusion

Injection vulnerabilities are still the most common and deadly web application attacks. In this paper we have represented SQL injection prevention using REGEXP (Regular expression) and did the analysis using Gradient Boosting Classifier algorithm. To perform the aforementioned, we either created our own dataset using Regular expression and tokenization OR imported dataset from any other trusted website. Data normalization techniques were used to sweep of any anomalies. Further , model training was done after dataset splitting in training and testing components. Tokenization method was again taken into consideration for model testing – resulting to successful model operation in classifying SQLI codes and normal / valid codes.

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