IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Vol.8, Issue.5, May 2020 E-ISSN: 2347-2693

Predicting Autism Spectrum Disorder Using Machine Learning Algorithms: A Review

Kalpana C.[1*], Anitha Kumari K.[2]

[1]Dept. of Information Technology, KGiSL Institute of Technology, Tamil Nadu, India
[2]Dept. of Information Technology, PSG College of Technology, Tamil Nadu, India

[*]*Corresponding Author: kalpana.satishkumar@gmail.com*

DOI: https://doi.org/10.26438/ijcse/v8i5.3136 | Available online at: www.ijcseonline.org

Received: 09/May/2020, Accepted: 18/May/2020, Published: 31/May/2020

***Abstract*—** Among many psychiatric disorders, Autism Spectrum Disorder (ASD) affects people in diverse ways. Nowadays the prevalence of Autism spectrum disorder has increased gradually worldwide. Difficulty in social interaction, trouble with speech and nonverbal communication, repetitive actions, avoidance of eye contact and abnormal facial expressions are the primary symptoms of ASD. Predicting ASD at an early stage is important to provide necessary developmental support. Machine Learning algorithms play a vital role in prediction of ASD. In this study, Machine Learning algorithms like Linear Discriminant Analysis (LDA), K-Nearest Neighbor (KNN), Decision trees, Random forest –CART and merging of Random Forest-CART and Random forest - Iterative Dichotomiser 3 (ID3) are compared for ASD prediction.

***Keywords*—**Autism Spectrum Disorder, Autistic Spectrum Disorders in Children and Adults, Machine Learning, Linear Discriminant Analysis, K-Nearest Neighbour, SVM, K-NN, Decision Trees, Random Forest CART & ID3.

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a group of complex neurodevelopment disorders that comprise Autistic disorder, Asperger disorder and Pervasive developmental disorder stated by the Centers for Disease Control and Prevention of the United States. Although some people with ASD can survive without depending on others, people have serious disorders need care and help throughout their lives. During the first five years of life the conditions are evident in most of the ASD cases. According to World Health Organization, 1 out of 160 children suffering from ASD. It begins in early childhood and tends to continue till adolescence and adulthood stage of life. Delay in the development of language is considered as a vital aspect of ASD. Around 50% of the people with autism cannot make useful communication.

The occurrence of ASD appears to be growing worldwide, in light of epidemiological studies led in the course of last 50 years. The apparent rise can be explained in many ways with increased understanding, extension of diagnostic criteria, improved diagnostic tools, and increased reporting. Environmental and genetic factors also raise the risk of an ASD in a child. Early diagnosis and intervention of autism is important that helps the patients to get right care and better support for their life. Therapies for Autism are available that make the affected children behave like near normal levels. Detecting ASD can be hard because there is no clinical examination similar to a blood test, for detecting the disorders. Based on the behaviour and development of the child, the doctors can diagnose this disorder.

To ease the diagnosing process and to predict the Autism Spectrum disorder in early stage Machine learning algorithms can be applied effectively. Machine learning is a division of AI and is associated to computational statistics. It also centers on prediction, making utilizing a computer. It has sturdy association to mathematical optimization, which offers techniques, model and application domain in the field [1]. Machine learning is a method which transforms the information into useful knowledge [2].

Machine learning is a discipline that emphases on creating computer systems that develop automatically through experience and Statistical theoretic laws that manage learning systems. In this study, we use Machine learning algorithms like Linear Discriminant Analysis (LDA), K-Nearest Neighbor (KNN), Decision trees, Random forest – CART and merging of Random Forest-CART and Random forest - Iterative Dichotomiser 3 (ID3) for the prediction of ASD.

The University of California contains a range of appropriate datasets for machine learning algorithms [3]. The data used in the study were acquired from a survey carried out by Thabtah [4]. The children Autism data set (4 to 11 age group) has 292 instances and the adult Autism data set (18 and above age) has 704 instances with 22 attributes which are the combination of categorical and numerical data. It contains 10 autism related questions followed by Age, Gender, Age, Ethnicity, If born with Jaundice, Family member with PDD, Who is completing

the test, country of Residence, used the screening app before, Screen method type.

The aim of this work is to review different machine learning algorithms in the prediction of Autism Spectrum Disorder among the children and adult. The paper is organized as follows: Section II presents literature survey, Section III discusses various machine learning algorithms, Section IV provides a comparison of results, and Section V presents the conclusion of the paper.

II. LITERATURE SURVEY

This section briefly elaborates the related works for the prediction of ASD. The machine learning algorithm plays a vital role in predicting ASD. ASD includes many behavioral disorders as indicators like social interaction and deficiency in communication, repeated patterns of behavior and activities. ASD existence estimate of 16.8 in 1,000 children in the age group of 8 years in 2014 is developed than earlier estimates [5]. KNN, SVM, Navies' Bayes and Decision Tree algorithms were applied to forecast the existence of Diabetic Retinopathy [6]. For breast cancer prediction, machine learning algorithms like Random Forest, KNN and Navies' Bayes were applied [7]. SVM and neural networks better perform for the prediction of coronary heart diseases [8].

A framework for ASD prediction using machine learning based on face scanning with eye gaze location was used [9]. Involvement of neuroanatomical networks in ASD can be detected with the help of a whole-brain classification method by applying Support Vector Machine (SVM) [10]. Linear Discriminant Analysis (LDA) and K-Nearest Neighbor (K-NN) algorithms were used for diagnosing ASD disease in children and LDA achieve better accuracy [11]. Engagement of Typically Developing (TD) children is much easier than children with ASD and examined the degree of children's involvement in contact with their parents [12].

Several acoustic features were examined and tested statistically to verify whether they are supportive for distinguishing between ASD and Typical Development (TD) using Support Vector Machine algorithm [13]. Autism Spectrum Disorder can be identified within 16-30 months of birth using Machine learning algorithms. 8 features out of 23 features are essential to categorize autism from normal by incorporating J48 algorithm [14]. Among many supervised machine learning algorithms, Support Vector Machine (SVM) and AD tree where the algorithms applied in common to the prediction of ASD [15]. To diagnose the proper type of autism, all possible ASD symptoms from the primary indications can be found by using machine learning and confabulation theory [16]. Many machine learning algorithms like KNN, SVM, Logical regression, Naive Bayes and LDA were applied to predict ASD among adults [17].

With the help of short screening test and validation, classification of Autism was performed. ADT Tree and function tree showed better result with high sensitivity, specificity and accuracy [18]. For ASD screening "red flags" tool was used [19]. The risk level of diabetes can be detected using Machine learning algorithms and Decision Tree algorithm provided high precision [20]. K- Mean Cluster analysis method was applied to classify challenging behaviors in ASD [21]. Combining Random Forest –CART algorithm and Random Forest–ID3 (Iterative Dichotomiser 3) algorithm a model was built for autism prediction provided high accuracy [22].

Deep learning algorithm and neural networks can be applied to find ASD patients with the help of large brain imaging dataset [23]. With the application of machine learning algorithms to produce a classifier that indicates a 0.72 decrease in length from the ADOS-G and provides statistical accuracy of 97% [24]. By applying machine learning, to assess whether only a subset of behavior is enough to differentiate from autistic children with normal children and found that out of 28 behaviors 9 are selected using Logical regression classifier and 12 in 28 behaviors are selected using SVM classifier with an accuracy of 98.27% and 97.66% [25].

III. ALGORITHMS USED

A. *Support Vector Machine*

It is a supervised learning algorithm and used for classification or regression problems. The aim of the support vector machine is to find a hyper plane in a multidimensional space. Many probable hyper planes can be selected to separate the two classes of data points. The goal is to locate a plane that has maximum margin. To classify the data points hyper planes are decision boundaries.

B. *Linear Discriminant Analysis*

LDA is a dimensionality reduction technique that is commonly used for the supervised classification problems. It is required to compute between-class scatter" matrix, and "within-class scatter" matrix. Within the class scattered matrix is given by the following equation.

Ai to n is the set of samples, xi to n is the class labels. within-class scatter matrix is given by equation (1),

$$S_w=\sum_{i=1}^{n}(a_i - m_{x_i})(a_i - m_{x_i})^T \quad (1)$$

m_{x_i} indicates the mean value of different classes and a represents the sample vector

Between class scattered matrix is given by equation (2),

$$S_b=\sum_{j=1}^{k} n_j\,(m_j - m)(m_j - m)^T \quad (2)$$

nj is the number of samples, m is the sample mean

Discriminatory power value is computed as equation (3)

$$C(Z) = (Z^T s_w z) / (Z^T s_b Z) \quad (3)$$

The Z^T indicates the optimal discrimination projection matrix by solving eigenvalue problem
$S_b Z = \lambda s_w Z$

Linear Discriminant function is given equation (4)
$B(x) = Z^T (a - m / z)$
(4)

C. K-Nearest Neighbor

It is the most widely used algorithm for classification since it has very less computation time. K-NN uses similarity of feature to foresee the values. Compute the distance between the test data and training data using Euclidean distance. The Steps followed in K-NN are follows: Select the nearest data point K, Compute distance, sort them in ascending order, select the minimum distance and allocate a class.

D. Decision Tree –CART

For developing the prediction model Decision tree-CART (classification and Regression Tree) classifier was taken. Initially the root of the tree has the entire dataset, then based on the best features the data splits takes place. In recursive manner, the process of splitting proceeds until all data are processed. Feature selection uses Gini impurity and Information gain (IG) as shown in equation (5) and (6). The feature that has maximum Information Gain (IG) will be selected initially to split data.

Gini (data) = 1- $\sum_{j \in classes} p(j)2$

for j=1 to number of classes
(5)

Information Gain (data, feature X) = Gini (data) – $\sum_{j \in features} Avg\ Gini\ (j)$
(6)

E. Random Forest – CART (Classification and Regression Tree)

The following steps represent the implementation of Random forest CART algorithm

- An Array is created for storing decision trees.
- N number of decision trees are created using create tree function and stored in the array.
- For each random attributes taken create decision trees.
- Voting is done for each decision tree based on this classifying test data occurs.

F. Merging of CART and Random Forest Iterative Dichotomiser 3 (ID3)

The steps involved in Merging of CART and Random Forest ID3:

For the creation of combined random forest classifiers, create an array and store n number of ID3 trees and CART trees built using tree construction procedure.

Building procedure for Iterative Dichotomiser 3 (ID3) and CART are similar, but ID3 uses Entropy to compute Information Gain (IG) and CART uses Gini impurity to compute IG. Voting is done for each decision tree of the combined random forest to classify the test data.

IV. RESULT ANALYSIS

A. Performance Evaluation

In this study, Accuracy, Sensitivity, Specificity, Precision and F-Measures are considered as evaluation metrics for the classification algorithms [26].

Accuracy is calculated as,
Accuracy = (TP + TN) / (TP + FN + FP + TN)
Sensitivity is calculated as,
Sensitivity= TP / (TP + FN)
Specificity is calculated as,
Specificity = TN / (TN + FP)
Precision is calculated as,
Precision = TP / (TP + FP)
F-Measure is calculated as
F-Measure = 2 ((precision x sensitivity) / (precision + sensitivity))

True positive (TP) represents the correctly predicted ASD patients, False positive represents that ASD positive patients are predicted as not ASD, True negative represents that ASD negative patients are predicted correctly as not ASD, False negative represents that ASD negative patients predicted as ASD patient. Support Vector Machine, Linear Discriminant Analysis, K Nearest Neighbor, Decision Tree, Random Forest- CART and Merging of Random forest CART and Random Forest- ID3 algorithms are compared for prediction of ASD in children by using UCI data set as shown in Table 1 and in Fig 1.

Table 1. Algorithm analysis for ASD in children

Algorithm	Accuracy	Sensitivity	Specificity	Precision	F Measures
SVM	81	88	86	83	85.42
LDA	90.8	95.24	86.67	86.96	90.91
KNN	88.5	97.62	80	82.00	89.13
Decision Tree CART	89.92	90.47	89.34	89.76	90.11
Random Forest CART	91.70	88.18	95.75	87.73	87.95
Merging Random forest CART and Random Forest ID3	92.26	96.52	88.52	88.09	92.11

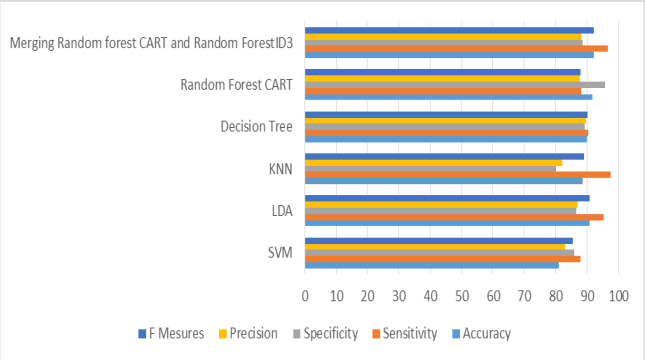

Fig 1. Comparison of algorithms based on evaluation metrics

Merging of Random forest CART and Random Forest-ID3 algorithm shows high Accuracy and F-Measures as 92.26% and 92.11 %. The KNN algorithm shows high Sensitivity as 97.62%. Random forest CART shows high specificity as 95.75% and Decision Tree shows high precision as 89.76%.

Comparison of SVM, LDA, KNN, Decision Tree, Random Forest- CART and Merging Random forest CART and Random Forest-ID3 for Adult data set as based on the Accuracy as evaluation parameters as shown in Table 2.

Table 2: Result analysis for ASD Adults

Machine Learning Algorithm	**Accuracy**
SVM	70.595
LDA	72.2024
KNN	67.556
Decision Tree CART	88.32
Random Forest CART	96.91

For Adult dataset, Merging of Random Forest CART and Random Forest ID3 provides high accuracy as 97.1%.

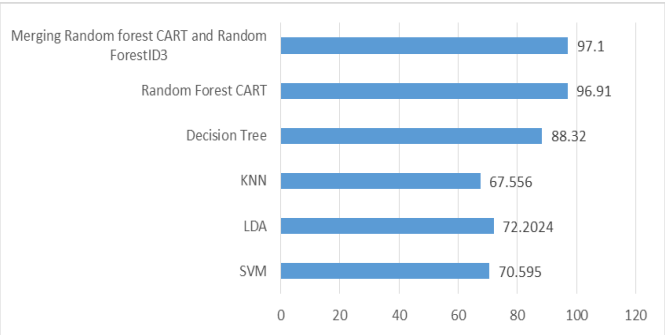

Figure 2. Comparison of algorithms based on Accuracy for ASD Adults

With the help of TP, TN, FP and NP values, the evaluation parameters like Accuracy, Sensitivity, Specificity, Precision and F-Measures are computed. Using the same machine learning algorithms prediction of ASD for adults based on accuracy as metric is compared. Accuracy indicates the correctly classified Autism patients by the algorithm out of all persons, Precision indicates the correctly positive labelled by the algorithm to all positively labelled. Sensitivity represents the correctly predicted ASD patients by algorithm of all Autism patients, Specificity represents the correctly predicted not ASD patients by algorithm out of ASD negative people. F-measure indicates the Harmonic average of Precision and Sensitivity.

For Autism Children dataset, by the application of SVM, LDA, KNN, Decision Tree, Random Forest- CART and Merging Random forest CART and Random Forest-ID3 algorithms, Merging Random forest CART and Random Forest-ID3 algorithm produced better Accuracy and F-Measures as 92.26 % and 92.11 % than other algorithms. K-nearest neighbor (KNN) algorithm provided better Sensitivity as 97.62% than other algorithms. Random Forest CART produced better specificity as 95.75% than others. Decision Tree CART provided better precision value as 89.76% than other algorithms. For Autism Adult dataset, Merging Random forest CART and Random Forest-ID3 algorithm produced better Accuracy as 97.10%.

V. CONCLUSION

In this study, Autism Spectrum Disorder in children and Adults were diagnosed by machine learning algorithms. Significant machine learning algorithms were utilized to reflect the complete performance of the machine learning algorithms in ASD. A dataset with 21 features was used in this work for prediction purpose. Machine learning algorithms like SVM, LDA, KNN, Decision Tree, Random Forest- CART and Merging Random forest CART and Random Forest-ID3 were applied for ASD children and Adults dataset and results were compared. These algorithms produced a noble performance in helping the autistic people. The combined form of Random forest CART and Random forest ID3 algorithm better performed than all other machine learning algorithms in terms of accuracy. In future we will propose a new machine learning algorithm or modify the prevailing algorithms in order to attain improved accuracy.

REFERENCES

[1] Louridas P and Ebert C., “Machine Learning,” IEEE Softw., vol. 33, no. 5, pp. 110–115, 2016.
[2] Jordan, M. I., & Mitchell, T. M. “Machine learning: Trends, perspectives, and prospects”. Science, 349(6245), 255–260. doi:10.1126/science.aaa8415, 2015.
[3] Lichman, M “UCI Machine Learning Repository Irvine”, CA: University of California, School of Information and Computer Science, 2013.
[4] Stevens, E., Atchison, A., Stevens, L., Hong, E., Granpeesheh, D., Dixon, D., & Linstead, E., “A Cluster Analysis of Challenging Behaviors in Autism Spectrum Disorder”. 2017 16th IEEE International Conference on Machine Learning and Applications (ICMLA). doi:10.1109/icmla.2017.00-85, 2017.
[5] Maenner MJ, Shaw KA, Baio J, et al., “Prevalence of Autism Spectrum Disorder Among Children Aged 8 Years — Autism and Developmental Disabilities Monitoring Network”, 11 Sites, United States, 2016. MMWR Surveill Summ 2020;69(No. SS-4):1–12. DOI: http://dx.doi.org/10.15585/mmwr.ss6904a1, 2016.

[6] Omar, K. S., Mondal, P., Khan, N. S., Rizvi, M. R. K., & Islam, M. N., " A Machine Learning Approach to Predict Autism Spectrum Disorder". 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE). doi:10.1109/ecace.2019.8679454, 2019.

[7] Satu, M. S., Farida Sathi, F., Arifen, M. S., Hanif Ali, M., & Moni, M. A. "Early Detection of Autism by Extracting Features: A Case Study in Bangladesh". 2019 International Conference on Robotics,Electrical and Signal Processing Techniques (ICREST). doi:10.1109/icrest.2019.8644357, 2019.

[8] Pal, R., Poray, J., & Sen, M, "Application of machine learning algorithms on diabetic retinopathy". 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT). doi:10.1109/rteict.2017.8256959, 2017.

[9] Liu, W., Yu, X., Raj, B., Yi, L., Zou, X., & Li, M., " Efficient autism spectrum disorder prediction with eye movement: A machine learning framework". 2015 International Conference on Affective Computing and Intelligent Interaction (ACII). doi:10.1109/acii.2015.7344638, 2015.

[10] Ecker, C., Rocha-Rego, V., Johnston, P., Mourao-Miranda, J., Marquand, A., Daly, E. M. Murphy, D. G., "Investigating the predictive value of whole-brain structural MR scans in autism: A pattern classification approach". NeuroImage, 49(1), 44–56.

[11] Altay, O., & Ulas, M., "Prediction of the autism spectrum disorder diagnosis with linear discriminant analysis classifier and K-nearest neighbor in children". 2018 6th International Symposium on Digital Forensic and Security (ISDFS). doi:10.1109/isdfs.2018.8355354, 2018.

[12] Chorianopoulou, A., Tzinis, E., Iosif, E., Papoulidi, A., Papailiou, C., & Potamianos, A., "Engagement detection for children with Autism Spectrum Disorder". 2017 *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*. doi:10.1109/icassp.2017.7953119, 2017.

[13] Mitsumoto, D., Hori, T., Sagayama, S., Yamasue, H., Owada, K., Kojima, MOno, N., "Autism Spectrum Disorder Discrimination Based on Voice Activities Related to Fillers and Laughter". 2019 53rd Annual Conference on Information Sciences and Systems (CISS). doi:10.1109/ciss.2019.8692794,2019.

[14] Satu, M. S., Farida Sathi, F., Arifen, M. S., Hanif Ali, M., & Moni, M. A., "Early Detection of Autism by Extracting Features: A Case Study in Bangladesh". 2019 International Conference on Robotics,Electrical and Signal Processing Techniques (ICREST). doi:10.1109/icrest.2019.8644357, 2019.

[15] Hyde, K. K., Novack, M. N., LaHaye, N., Parlett-Pelleriti, C., Anden, R., Dixon, D. R., & Linstead, E., " Applications of Supervised Machine Learning in Autism Spectrum Disorder Research: a Review". Review Journal of Autism and Developmental Disorders. doi:10.1007/s40489-019-00158-x, 2019

[16] Dutta, S. R., Datta, S., & Roy, M., " Using Cogency and Machine Learning for Autism Detection from a Preliminary Symptom". 2019 9th International Conference on Cloud Computing, Data Science & Engineering ,2019.

[17] Tyagi, B., Mishra, R., & Bajpai, N., " Machine Learning Techniques to Predict Autism Spectrum Disorder". 2018 IEEE Punecon. doi:10.1109/punecon.2018.8745405, 2018.

[18] Wall, D. P., Dally, R., Luyster, R., Jung, J.-Y., & DeLuca, T. F., "Use of Artificial Intelligence to Shorten the Behavioral Diagnosis of Autism". PLoS ONE, 7(8), e43855. doi:10.1371/journal.pone.0043855, 2012.

[19] Allison, C., Auyeung, B., & Baron-Cohen, S. " Toward Brief "Red Flags" for Autism Screening: The Short Autism Spectrum Quotient and the Short Quantitative Checklist in 1,000 Cases and 3,000 Controls". Journal of the American Academy of Child & Adolescent Psychiatry, 51(2), 202–212.e7. doi:10.1016/j.jaac.2011.11.003, 2012.

[20] Sonar, P., & JayaMalini, K., " Diabetes Prediction Using Different Machine Learning Approaches". 2019 3rd International Conference on Computing Methodologies and Communication (ICCMC). doi:10.1109/iccmc.2019.8819841, 2019.

[21] Granpeesheh, Dennis Dixon and Erik Linstead.," A cluster Analysis of challenging Behaviors in Autism Spectrum Disorder". 2017 16th IEEE International Conference on Machine Learning and Applications (ICMLA), 2017.

[22] Omar, K. S., Mondal, P., Khan, N. S., Rizvi, M. R. K., & Islam, M. N.,"A Machine Learning Approach to Predict Autism Spectrum Disorder. 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE). doi:10.1109/ecace.2019.8679454, 2019

[23] Heinsfeld, A. S., Franco, A. R., Craddock, R. C., Buchweitz, A., & Meneguzzi, F. " Identification of autism spectrum disorder using deep learning and the ABIDE dataset. NeuroImage": Clinical, 17, 16–23. doi:10.1016/j.nicl.2017.08.017, 2018.

[24] Duda, M., Kosmicki, J. A., & Wall, D. P., " Testing the accuracy of an observation-based classifier for rapid detection of autism risk". Translational Psychiatry, 4(8), e424–e424. doi:10.1038/tp.2014.65, 2014.

[25] Kosmicki, J. A., Sochat, V., Duda, M., & Wall, D. P. "Searching for a minimal set of behaviors for autism detection through feature selection-based machine learning". Translational Psychiatry, 5(2), e514–e514. doi:10.1038/tp.2015.7, 2015.

[26] Jain, A., & Huang, J., " Integrating independent components and linear discriminant analysis for gender classification". Sixth IEEE International Conference on Automatic Face and Gesture Recognition, 2004. Proceedings. doi:10.1109/afgr.2004.1301524, 2004.

[27] Aparna Shenoy, K.V. Viswanatha, Raju Ramakrishna Gondkar, "Early Sepsis Prediction in Intensive Care Patients using Random Forest Classifier", *International Journal of Computer Sciences and Engineering*, Vol.8, Issue.1, pp.17-22, 2020.

[28] Rosy Mishra, Y. Sowjanya, Sushanta Meher, Mousumi Meher, "A Voice Signal Interpreter using Machine Learning Techniques," *International Journal of Scientific Research in Network Security and Communication*, Vol.8, Issue.2, pp.22-27, 2020.

Authors Profile

Mrs. C. Kalpana is working as an Assistant Professor in Department of IT in KGiSL Institute of Technology, India. She received her B. Tech degree in Information Technology with Distinction from Anna University, Chennai and M.E degree in Computer Science and Engineering with Distinction from Anna University, Chennai. She secured university rank in her Post Graduation. She is interested in learning new stuffs. Her research interests are in the field of Big data and Machine learning.

Dr K Anitha Kumari is working as an Associate Professor in Department of IT in PSG College of Technology, India. She is Highly Passionate and curious about Learning New stuffs in Security Protocols. As an Independent Researcher, she had an Opportunity to present her UGC sponsored paper based on Quantum Cryptography in USA and visited a few Foreign Universities. To her credit, she had filed a PATENT and published around 55 Technical Papers in refereed and Impact Factored International/National

Journals/Conferences published by Elsevier, Springer, T&F, etc.,.Also, she's been an Active Reviewer for Prestigious Journals published by IEEE (IEEE Communications Surveys and Tutorials (IF: 20.230), IEEE Transactions on Industrial Informatics (IF: 5.43)), IEEE Access, Springer, Wiley, etc., and Technical Program Committee (TPC) for CECNet 2017, NGCT-2017 WICC-2018 and NCCI-2018 conferences. Her areas of interest include Cloud & IoT Security, Design and Analysis of Security Protocols, Attacks & Defense, Security in Computing, Bioinformatics, Cognitive Security, Quantum Cryptography, Web Service Security, Network Security and Analysis of Algorithms. Out of her research interest, she has contributed book chapters published by T & F, Springer and delivered ample Guest Lectures. Her security project is sanctioned and granted by AICTE for a sum of Rs.11,80,000/-. She's been the mentor for Technovator Projects (2019, 2018 & 2014) and 'MEDROIDZ', an ICICI – Trinity 2014 funded project that was selected as one among the 6 projects in India. She also mentored 5 projects exhibited in NST Fair and AICTE Vishwakrama Award Project. Academically, she has secured RANK-I and awarded Gold Medal in ME (SE) & in BE (CSE) from Anna University and from Avinashilingam University. She secured Elite+Gold Medal (Top 1%) in NPTEL – Cloud Computing course. She also won prizes in intra and inter institutional cultural events. As a Supervisor, she is currently guiding PhD scholars in her research area. Currently she's being the Programme Coordinator for PSG CARE Sponsored One Year Certification Course on Cyber Security. You may contact her at anitha.psgsoft@gmail.com / kak.it@psgtech.ac.in.

