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Enhancement to Smart Cities in Sri Lanka using Cutting Edge Technologies

Dissanayake D.M.C.Y.[1], Abineshh U.[2], Zihara M.I.F.[3], Kuruppu S.G.[4], De Silva D. I.[5] and Vidhanaarachchi S.[6]
[1]Undergraduate, Department of Software Engineering, Sri Lanka Institute of Information Technology, SRI LANKA
[2]Undergraduate, Department of Software Engineering, Sri Lanka Institute of Information Technology, SRI LANKA
[3]Undergraduate, Department of Software Engineering, Sri Lanka Institute of Information Technology, SRI LANKA
[4]Undergraduate, Department of Software Engineering, Sri Lanka Institute of Information Technology, SRI LANKA
[5]Lecturer, Department of Software Engineering, Sri Lanka Institute of Information Technology, SRI LANKA
[6]Lecturer, Department of Software Engineering, Sri Lanka Institute of Information Technology, SRI LANKA

[2]Corresponding Author: uabineshh@yahoo.com

ABSTRACT

Advancement of technologies leads to greater innovative ideas and optimal solutions to real world problems. In Sri Lanka the "Port City" currently undergoing construction is an extension of land from Sri Lanka in which the goal is to build a self-sustainable city along with a mixed diverse community. The best use case to demonstrate the usage of modern technologies and the aim of this study is to turn the concept of a city into a "Smart Port City" which solves many different components in the 11th sustainable development goal, sustainable cities, and communities through the utilization of advanced technologies such as artificial intelligence, machine learning, internet of things and blockchain in the form of a web application. Through this research, every aspect of a generic web application in terms of raw performance, security and privacy and convenience is outperformed by "Smart Port City" because of the utilization of modern technologies. The work done to implement and incorporate these technologies into a web application is extensively described with architectural diagrams. Additionally, deep dives into literature reviews was conducted to depict comparisons between before the usage of the advanced technologies and after the usage to interpret the results and findings to finally come to a decisive conclusion.

Keywords-- Smart City, Sustainability, Sustainable Development Goals, Artificial Intelligence, Machine Learning, Blockchain, Internet of Things

I. INTRODUCTION

Some of the global challenges people face are addressed by a set of Sustainable Development Goals. Sustainable development refers to a system that utilizes resources in such a manner that those are conserved for current and future generations. Those Sustainable Development Goals, which consists of 17 goals and 169 targets, are suggested by Open Working Group created by UN General Assembly at the UN in New York [1].

Cities acts as the central location of social progression, technological innovation, and economic development. But with the emergence of urbanization, cities faced some crucial challenges such as congestion, environmental degradation, and health hazards, which led to the collapse of the sophisticated lifestyle. These challenges aroused the demand for a smart port city. Smart cities refer to a methodology of enhancing city planning, management, and service delivery by means of the best usage of technologies, data, and available resources [2]. The best aspect about Smart Port City is its proximity to open green spaces, hospitals, restaurants, hotels, and places to entertain. A poor distribution of open public spaces in most regions is identified from data collected in 2020 from 1,072 cities. Only about 38 percent of urban areas were within 400 meters of an open public space, implying that only 45 percent of the global urban population had easy access to those spaces [3]. This fact verifies that open green spaces are far from us in our urban lives. Hence, smart cities cater to the immediate requirement of providing improved health, essential services, affordable housing, connectivity, places of recreation and relaxation for citizens.

The smart port city concept targets substantive support, especially for the thematic issue known as urbanization. The prime objective of developing a smart port city is to tackle the Sustainable Development Goal 11 named Sustainable cities and communities, which addresses the subject "Make cities and human settlements inclusive, safe, resilient and sustainable". With the development of smart port city, efforts to achieve some of the Sustainable Development Goal 11 targets such as "By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries" [3] and "By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and differently abled" [3] will be accomplished. Thus, this concept promotes sustainable

human settlements development.

Smart port city leverages innovative technologies such as Machine Learning (ML), Artificial Intelligence (AI), Blockchain, and the Internet of Things (IoT) to enhance the performance of the web application and usage of optimal technologies as solutions to counter problems that undeniably exists.

II. LITERATURE REVIEW

This research tackles the 11th sustainable development goal in a different perspective from what the raw definition of "Sustainable Cities and Communities" states. Although the raw definition of this is true and is a real problem, in 2022 the existing generations have evolved alongside the rapid advancement of technologies hence creating other problems that can result in the collapse of the entire community due to its effects, and thereby making cities unsustainable to inhabit. Some of these new problems includes security of systems, unreliable banking systems or voting systems, irrelevant ads specific to user and more.

Countless research has been conducted with respect to problems involving access to basic services, energy, housing, and transportation and tackling them with generic technologies, without considering the current trends in this rapidly growing generation alongside with technology. Hence more advanced technologies must be used to counter these problems such as artificial intelligence, machine learning and blockchain.

A study was conducted by Aamir. M. et al on the analysis of power system operation in smart cities to make power systems more energy efficient [4]. There are some problems in this research, one problem is that the research used a framework to make the system more efficient by implementing smart girds. However, a more optimal and advanced way to do this would be using machine learning. Through machine learning we can train the model with large amount of data sets to predict the distribution of energy to areas consuming low energy levels and reduce the throughput, thus reducing the energy dispersion due to heat. Machine learning models would evolve and mature with time as data is collected constantly making predictions more accurate. Another study by F. G. Brundu et al is also working towards the same approach however using internet of things (IoT) [5]. Security and privacy of data transmitted by the device would be vulnerable, hardware limitations, data loss due to disasters and its higher cost would not make this approach impractical although the concept is viable. However, by using a combination of both artificial intelligence and machine learning, we can greatly improve the security through facial recognition to access the IoT devices.

	Sustainable Cities and Communities (11th SDG)	
	Solved using outdated technologies	***Solved using modern technologies***
Energy	✓	
Air Pollution	✓	
Conjestion	✓	
Inadequate housing	✓	
Lack of funds	✓	
Security		✓
Fraud / Authenticity		✓
User Specific Ads and Information Intellegence		✓

Table 1: Research Gap

There is a large research gap between the common problems in the 11th sustainable development goal and new problems that has risen due to the advancement in technology which has caused cities and countries to collapse and communities untrusted and frightened. An example of this would be centralized banking systems. For many this may seem to not be a major issue, however if there is a situation where the bank goes bankrupt due to inflation for example, it the people's saved money which will be frozen or lost due to the banks centralized nature. However, this can be solved by using decentralized system such as blockchain technology. Through this there would not be a single point of control or failure which would increase the durability of the system as all nodes are distributed and because the system is blockchain modifications to transactions or records cannot be done hence increasing the authenticity as well.

III. WORK DONE

Smart Port City web application was built to solve the 11th sustainable development goal which would arise after the construction of the "Port City". The technology stack used to build the application was using the combination of MongoDB database, which is a NoSQL document database, Express as our web framework, ReactJS as our frontend and NodeJS as our backend. This technology stack is commonly known as MERN.

Below shows a high-level architectural diagram of the MERN web application.

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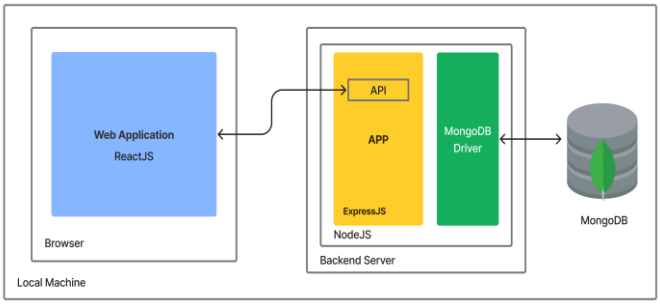

Figure 1: High level architectural diagram

Smart Cities are the rising trend in which volumes of paperwork, authentication issues, time consumption is reduced and where networking and communication, availability, scalability, privacy and security, efficiency is increased. Smart Port-City uses Machine learning, Blockchains, Artificial Intelligence and Internet of Things (IoT) to reach all these goals and to meet the sustainability development goal of making sustainable cities and communities in which it plans to make cities and human settlements inclusive, safe, resilient, and sustainable. These technologies help to store, organize, and manage large amounts of data while making the time to process and respond to user requests extremely low.

Additionally, smart port city uses blockchains to store and manage large amounts of data in a decentralized database. It uses digital identities for the occupants in the city. Here, each user's personal history, medical history and crime history is all maintained encrypted and with concrete security. This helps the doctors to treat patients, policeman to investigate and defines the analytics of a person. For the MERN application, it helps to auto-fill in the data in forms (example: registration form). Here, decision trees are used as the prediction method in ML to auto-fill the required forms.

Furthermore, smart port city also uses biometrics such as fingerprints and face recognition to authorize and authenticate users. This makes it easier for users as they can scan their faces and login to the web application and use the same biometrics to automatically complete transactions online in which they only must scan their faces so that money can be deducted from the bank accounts instantly. Data is gathered from the registered users in the Smart Port City. A data set is maintained and stored containing features and photographs of registered users. This makes it easier to sort data rather than having a large bulk of random data. This data is stored securely using a blockchain. Using this data set, a simpler version called a 'model' is developed so that the recognizer (IoT device) can be trained to retrieve data fast from the larger data set easily. This saves time and energy. The users position their faces to the IoT device(recognizer). This footage is recorded and sent to the trained model after processing the image and cropping the face. A message is then displayed predicting whether the face matches that of the images of gathered data. The process is real time and is done mainly using machine learning and IoT.

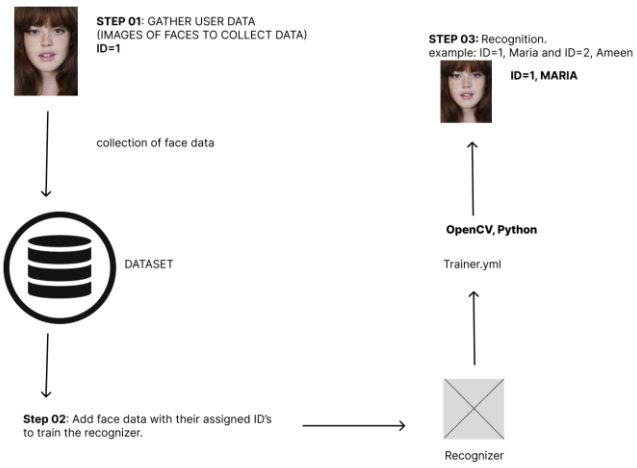

Figure 2: Process of AI facial recognition

Blockchains are integrated with smart devices and hence uses IoT to control devices in hotels, restaurants, hospitals, residencies, and sports clubs. Users in the smart port city does not need to go venturing for products physically. Their food, medicine etc. can be brought to their own doorstep by only a few steps using blockchain. For example, User A, a registered user of smart port city can easily order her favorite food by choosing what she needs and pay using face ID and complete the transaction successfully. All the services in the smart port city uses blockchain to store transaction data in decentralized ledges so that all the data of the transaction including the timestamps and unique cryptographic signatures which makes a transaction complete and easier for the financial audits to do their job. The transparency of the transaction is role based for the public, workers, CEO, and admins separately.

To complete the payment via face recognition, data is gathered in the initial stage. Card payment details and the photograph of the registered user previously collected is stored as an encrypted data set using blockchain. When the user's face is read in the IoT camera, the data gathered is validated with the data set of registered users in the blockchain using ML neural networking prediction method. Using ML, it is then predicted if the user is registered and valid. To ensure the accuracy of the reading, the algorithm is trained well using the data set. Image processing using ML is also done to match the user reading and registered user photograph. When the prediction method is done, a token requesting to complete the banking process is sent to

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the bank. The bank will then complete the transaction and send a message to the user implying that the payment process is successful and complete.

The admins of the MERN application could monitor the behavior and detect unusual behavior through CCTV connected to the web application using AI and machine learning. This increases the environmental security of people and their property and makes it easier to catch criminals. Rather than reviewing the footage from a normal CCTV that is not integrated with AI, CCTV with AI technology can detect criminal or unusual activity instantly and real time and alert the warning instantly. Using AI, the suspects clothes also can be detected. CCTV of a geographical location is remotely controlled and monitored through a portal in the MERN web application of the Smart Port City. This brings us closer than ever to our goal to make cities and settlements inclusive, safe, resilient, and sustainable. For this application, we have used ML and IoT prominently.

The energy consumption of the geographical location of the connected services is tracked using AI and ML and this makes it easy to manage resources and to meet the goals of sustainability.

Accordingly, the Smart Port City uses AI, ML, IoT and a blockchain to manage large amounts of data in an organized and sorted manner so that data could be easily retrieved instantly. It has reduced unnecessary cost and energy over paperwork, security, manpower etc. and has undeniably improved security, time, and interaction. It is evident that Use of AI, ML, Blockchain and IoT has helped to achieve our goal to make cities and settlements inclusive, safe, resilient, and sustainable by applying them in CCTV to detect crime, cameras to predict faces, to conduct financial transactions easily and to detect levels of energy consumption.

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IV. RESULTS AND DISCUSSION

Normally, developers' expectation is to provide least human–computer interaction with the web application to give a better user experience. Users should be able to easily go through the sign up and login processes. Currently, some password-related concerns include the usage of quite long passwords to secure accounts from third parties, reuse of the same password on several occasions, and struggling to reset forgotten passwords. Consequently, creating and managing passwords has become difficult with the hectic lifestyle.

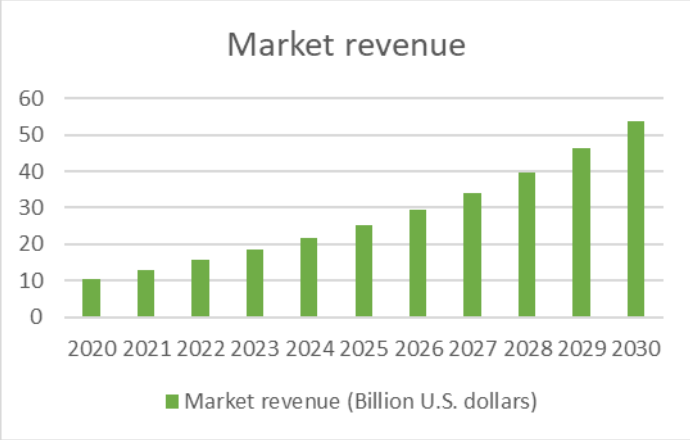

Figure 3: Passwordless authenication market reveune

The Figure 3 illustrates password-less authentication market revenue worldwide from 2020 to 2030, a decade. This authentication method does not require the use of passwords and consists of various benefits such as high security and enhanced user experience. Overall, the password-less authentication market revenue is expected to have a gradual increase over the period. So, our system uses password-less authentication for login to make it convenient for users. It allows users to efficiently log into the web application within a few seconds.

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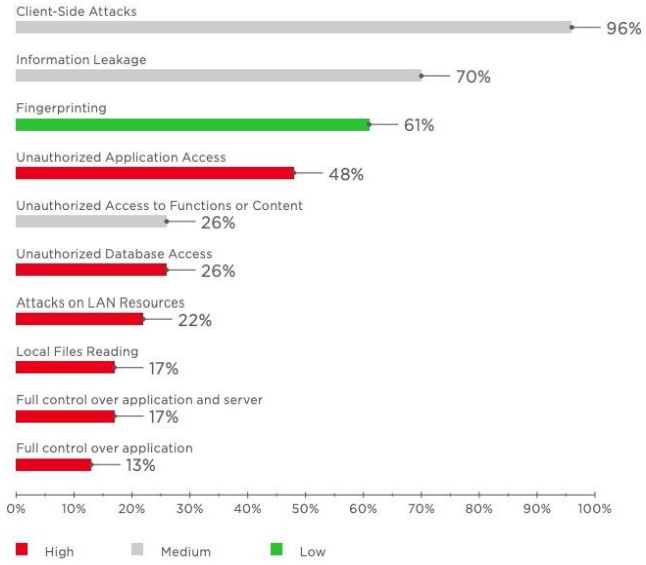

Figure 4: The frequency of threats in web applications in the year 2017

According to a survey conducted in 2017, 96 percent of web applications were vulnerable to attacks against users. There is an upsurge in data leaks including sensitive data. In approximately half of the test cases, there was the possibility of unauthorized access to an application.

Thus, it is evident that web applications can be successfully attacked if attempted. The outcomes of that research demonstrate the necessity of providing high security for web applications. As a result, we suggest biometric techniques such as facial recognition (FR) and iris scanning to prevent vulnerabilities.

FR system uses the machine learning algorithm type known as deep convolutional neural networks (DCNN) to extract required characteristics of a face. Three various standard machine learning algorithms such as Support Vector Machine (SVM), Decision Tree (DT) and K-Nearest Neighbor (KNN) was used to test the suggested recognition technique. The SDUMLA-HMT database, which was collected in 2010 by Shandong University in China, was used to analyze the suggested system. We have focused only on the iris and face databases.

The graph given below compares the four algorithms SVM, DT, KNN classifier and the suggested DCNN.

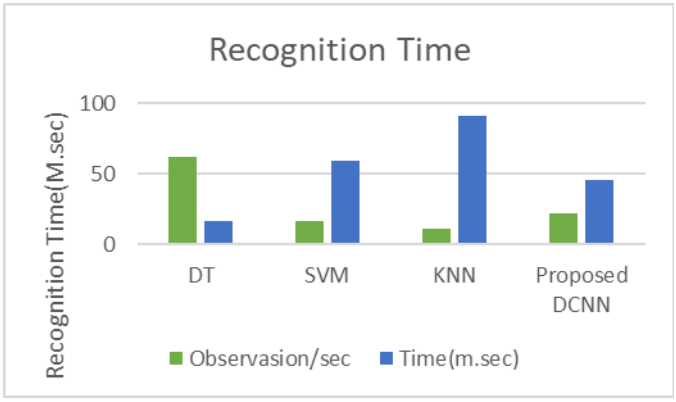

Figure 5: Recognision time of suggested FP system and individual classic

According to the Figure 5 results, the suggested DCNN perform better than other machine learning algorithms.

Three datasets such as SDUMLA-HMT, CASIA and 113 were used to identify the precision of the four algorithms and the graph given below was obtained.

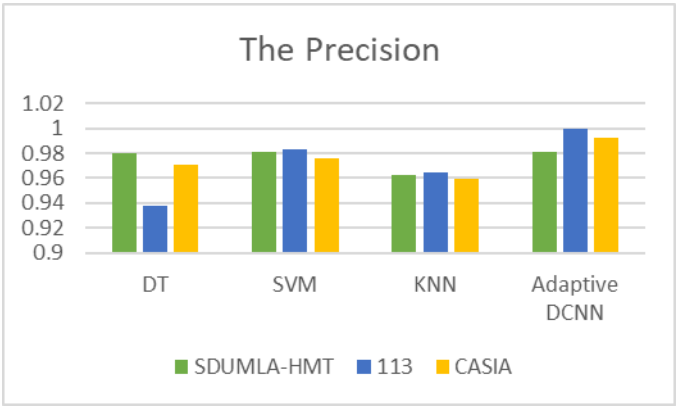

Figure 6: Precision of suggested FR system and the three other systems

The observations taken from CASIA and 113 datasets show that the suggested machine learning algorithm, DCNN has a significantly high precision. While the SDUMLA-HMT dataset, shows an equal precision level for both SVM and suggested DCNN algorithms. Therefore, according to the results obtained through the analysis of datasets, the suggested DCNN performs better than other machine learning algorithms.

The graph given in Figure 7. represents the accuracy of the suggested machine language algorithm in comparison to the other four algorithms using three datasets such as SDUMLA-HMT, CASIA and 113.

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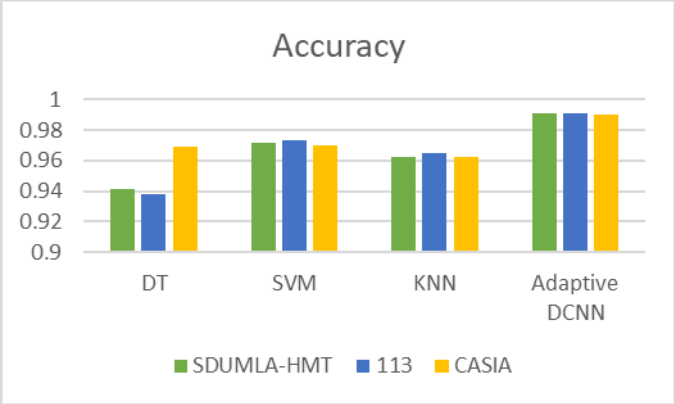

Figure 7: Accuracy of our proposed system and the three comparison systems.

According to the results obtained through the analysis of datasets, the suggested DCNN is much better than other machine learning algorithms in terms of accuracy.

The figure 8 gives information about the dramatic increase in the number of blockchain based wallets.

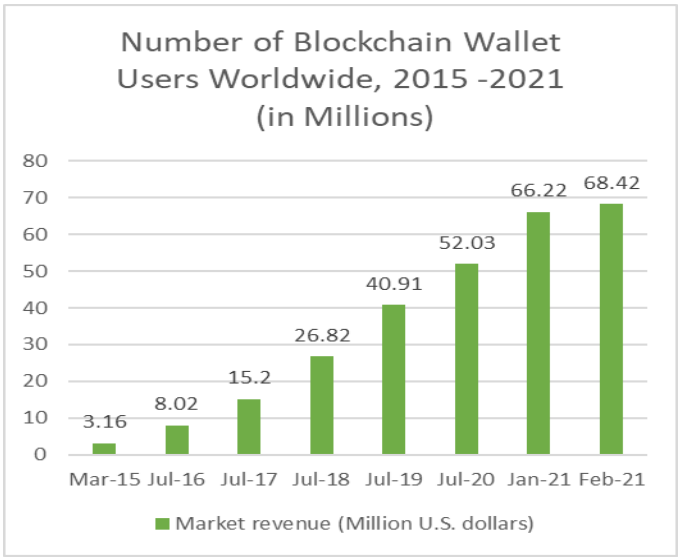

Figure 8: Number of Blockchain Wallet Users 2015-2021

The prime reasons for incorporating the blockchain technology for our system is because of its efficiency, decreased costs of data transfer and high security of transactions. The dynamic hash and cryptography implemented at each stage of the transaction makes it highly secure.

With the implementation of advanced protocols, each transaction is validated. Those transactions cannot be separated since smart contracts are integrated in the blockchain network.

One of the significant facts about blockchain is that it is decentralized that means there is no central authority which controls or receives data through blockchain. There is no specific device to be attacked. Thus, it avoids the possibility of handling data by intruders.

"Smart Dubai is a city that is totally powered by blockchain technology. It was a scheme for the development of a blockchain-based city with fully featured blockchain implementations" [6]. The blockchain market size is expected to have a rapid increase in the years ahead.

V. CONCLUSION

The proposed modern cutting-edge technologies can outperform every existing problem in the 11th sustainable development goal in a more optimized way while also solving new problems that has emerged due to the advancement in technologies. Though the incorporation of technologies as such as artificial intelligence, machine learning and blockchain, the web application had a significant increase in security by considering factors such as accuracy, precision, recognition time etc. Additionally, through blockchain technology the rate of fraud and decentralization of transactions would allow communities build trust and move forward without any inequality. Quantitative and qualitative data illustrated in the results and discussion section proves the beneficial effects of using these cutting-edge technologies to maintain sustainable cities and communities. [7]

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