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DESIGN OF CLOUD-BASED INTELLIGENT PLATFORM FOR INCIDENTS MANAGEMENT & PREDICTION USING MACHINE LEARNING

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Abstract:

Advances in data collection and storage infrastructure present a once-in-a-generation chance to integrate both data and emergency resources in each location into a dynamic learning system capable of anticipating and swiftly responding to situations involving different types of hazards. Currently, incident details are not always thoroughly documented and may be described in a variety of formats. Consequently, finding major issues in accident reports is a time-consuming and error-prone process. We tend to respond to the incidents manually and in a different way for the same exact incidents, even if the incidents have happened before. It makes the analysis task more difficult, affects the correction deadline of incidents as well as involves a high risk in terms of financial and workers' well-being. This paper discusses the design of an online incident report by exploiting the advances in cloud computing and the Internet of Things (IoT). This system will support incident analysis and incident prediction using collected incident data. Various strategies in the literature focus on assessing attributes and forecasting occurrences for specific conditions, but when used in a more significant and generic scenario, these models are ineffective. To account for these characteristics, we propose the use of machine learning (ML), specifically Similarity-Based Agglomerative Clustering (SBAC) analysis, to cater to various types of incidents of a generic nature. The proposed platform's principal objective is to predict the probability of the occurrence of a hazardous incident and execute rectification actions

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before the incident occurs. It can help organizations predict the likelihood of a fatal incident or accident occurring in the near future by analyzing historical data. This solution will help to improve overall safety ratings, as well as employee health, cost savings, and new project growth.

Keywords:

Risk; Hazard; Incident Prediction; Machine Learning; Cloud Computing

Intoduction

The way that safety is managed at work is referred to as the safety culture. It is the result of a person's beliefs, perceptions, and attitudes about their own safety as well as the general safety of the workplace. The creation of a safety culture must be given top priority if workplace safety is to be maintained (Pidgeon, 1991). Given that the primary purpose of culture is to support an organization's performance, organisational culture, whichever it is defined, is universally accepted to be essential to an organization's success or failure. The management of safety-related parts of a company's activities is regarded as essential. A good safety culture encourages individuals to worry about undesirable outcomes (Turner, 2019). Companies that are successful in fostering this widespread display of concern for safety will urge their employees to exhibit concern for how their actions impact both the physical world and other people. Organizations all around the world are impacted by workplace accidents, which can permanently harm their assets, resources, and reputation. The effects of fatalities and injuries at work extend beyond the wounded worker. Additionally, the effects on the neighbourhood (i.e., family members and friends), workplace (i.e., coworkers and employers), and larger society have been noted (Aburumman et al., 2019). But how did we come to develop our personal sensitivity to the subject in the first place? One must take some of the changes into account while posing such questions in incident management in the organization.

According to Safety Culture (2022), the process of identifying and analysing risks and hazards in order to develop mitigation and control strategies that will effectively reduce the impact of incidents, restrict their ability to interrupt operations, and stop them from happening again is known as incident management. There are several terms used in safety culture that is commonly used in incident reporting and incident management. These terms are (i) near-miss, (ii) incident, and (iii) accident. An unanticipated incident is called a "near-miss" if it had the potential to cause property damage, injury, disease, or death but did not. To help operations, improve procedures and get rid of or reduce dangers, it's imperative to report every near-miss that occurs at work. An incident is a regrettable occurrence that interferes with routine business and makes it harder to get things done. Like near-misses, incidents have not led to injury, death, or property damage, but they can also be potentially destructive events. A negative effect on the organisation may result from the occurrence of an incident that presents dangers or threats to a company's personnel. On the other hand, an accident is a sudden, unanticipated event that causes property damage, disease, physical harm, or even death. Sometimes people confuse the terms "accidents" and "incidents," although there are differences depending on what caused them. For instance, accidents are typically unpreventable, uncontrollable random events for which no deliberate preventive action was taken to lessen or prevent their occurrence. Incidents, on the other hand, are seen as "predictable and could have been prevented if the right actions were taken" (Anderson et al., 2004; Safety Culture, 2022). Various other definitions of hazard, risk, incident and accident exist as shown in Table 1 below.

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Table 1: Definition of Hazards, Risks, Accidents, and Incidents

Safety	Definition 1	Definition 2	Definition 3	Definition 4
Hazard	There is something which has a potential to cause harm (HSE STUDY GUIDE, 2020)	It is a potential which may lead to injury, property damage or environmental effect (HSE STUDY GUIDE, 2020)	anything that could potentially injure something or someone, or have a negative impact on their health (CCOHS, 2022)	situations that put people in danger of getting hurt, ill, or even dying
Risk	The likelihood that exposure to a risk may cause injury or have a negative impact on one's health (HSE STUDY GUIDE, 2020)	The likelihood that something may occur and cause harm (Government of Western Australia Department of Mines, Industry Regulation and Safety, 2022)	The likelihood, whether high or low, that any risk will result in injury (CCOHS, 2022)	The likelihood that the risk will result in harm and the potential severity of that harm (Cushenan S, 2021)
Accident	It is an undesired, unplanned event which resulted in an injury or death or damage to property or environment (HSE STUDY GUIDE, 2020)	An occurrence that causes harm or illness (HSE)	An unintentionally caused event (safeopedia, 2021)	An unexpected and uncontrolled incident when bodily injury is caused by the action or reaction of a person, object, chemical, radiation, or the likelihood of it (OSH WIKI)
Incident	Any untoward an unplanned occurrence which resulted or could have resulted to physical injury or death to person or damaged to property or environment (HSE STUDY GUIDE, 2020)	An occurrence that doesn't already cause harm but could lead to illness or injury	A near-miss or an undesired circumstance	An incident is referred to as an occurrence arising out of or in the course of work that could or does result in injury and ill health (OSH WIKI)

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Six fundamental characteristics of problems, incidents, and crises have been researched, with an emphasis on their distinguishing features that are crucial for preventive action (Luburić, 2019). Concerning predictability, it can be noted that problems are predictable, occurrences are typically predictable, however crises are distinctive, uncommon, and typically unexpected. The primary objective of incident management is to enable an organisation to resolve its day-to-day issues and potential events effectively and efficiently before they escalate into a crisis. This can be achieved using effective Incident management systems. Incident reporting is important in an incident management system to promote a safe culture. The primary way of producing alert signals about the supply of a quality working environment is incident reporting. Only 1% of instances are reported, though (Haji Mohammadi et al., 2018; QUE, 2018). Worker inefficiency and communication bias are both exacerbated by a lack of knowledge. This restricts the creation of safety measures (Dhamanti et al., 2020). To improve incident reporting, raise awareness of reporting obligations among the public, enhance risk communication, and raise the standard of safety, common sense and doable solutions should be established (Varallo et al., 2018).

Even the advent of cloud computing has necessitated management ideas and procedures created especially for cloud computing services. When implementing and using cloud services, management principles and procedures are extremely important for users (Karkošková, 2018). Sources of data for managing hazards and risks include textual data entered by safety officers in an organization of interest (for example Occupational Safety Officers for universities and schools). Textual data include the incident information that explains the end-problem. User can find patterns in this data using standard reporting or analytical tools such as Excel. However, this process is time-consuming and error-prone. Numerous problems lead to incidents going undiscovered if the identification of patterns is incomplete, which is particularly probable when humans are responsible for spotting patterns in data. Automating the analysis through advanced intelligence can provide a comprehensive, 360 view of risks and helps to identify and monitor emerging risks before they can have a significant impact on the organization. Machine learning algorithms are rapidly being leveraged across many industries to analyse occupational injury and incident data and build predictive models that can drive cost savings and reduce incident probabilities. Incident prediction using the negative binomial distribution (Wang et al., 2019), artificial neural networks (Cortez et al., 2018), and hierarchical analysis (Hu et al., 2017) utilized to great effect when attempting to anticipate incident frequency for specific areas and have assisted in identifying roadway characteristics that influence incident incidence.

System's Objective

This system is designed to assist Safety Managers of any organization and institution (such as universities, schools, offices) to manage hazards (such as faulty stair railing guide or faulty lamp switch) and risks (such as students falling from stairs because of the faulty rail guides and workers being electrocuted when they use a faulty lamp switch). This system can also be used to record incidents and accidents due to the risk and hazards (such as a student falling from stairs and workers that were electrocuted when using the faulty switch). For this system, the research team uses the term accident to denote incidents that cause severe repercussions. We also denote accidents as highly unpredictable compared to incidents which could be predicted by analysing the occurrence of previous incidents and the existence of risks using Machine Learning (ML).

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The use case for the system is that users (risk officers or managers) define and input all potential risks and incidents that have occurred that can be encountered by an institution in the system. At the same time, users can also key in or report hazards and risks that they encounter using mobile applications. The system's analytical engine will consider the registry of potential risks and hazards, pair them with near-miss incidents as well as observed incidents and predict the occurrence of such incidents in the future. The list of potential risks and hazards that can occur in the future is presented to the risk and safety officer and manager, who will then take immediate action to rectify the risk and prevent incidents from occurring.

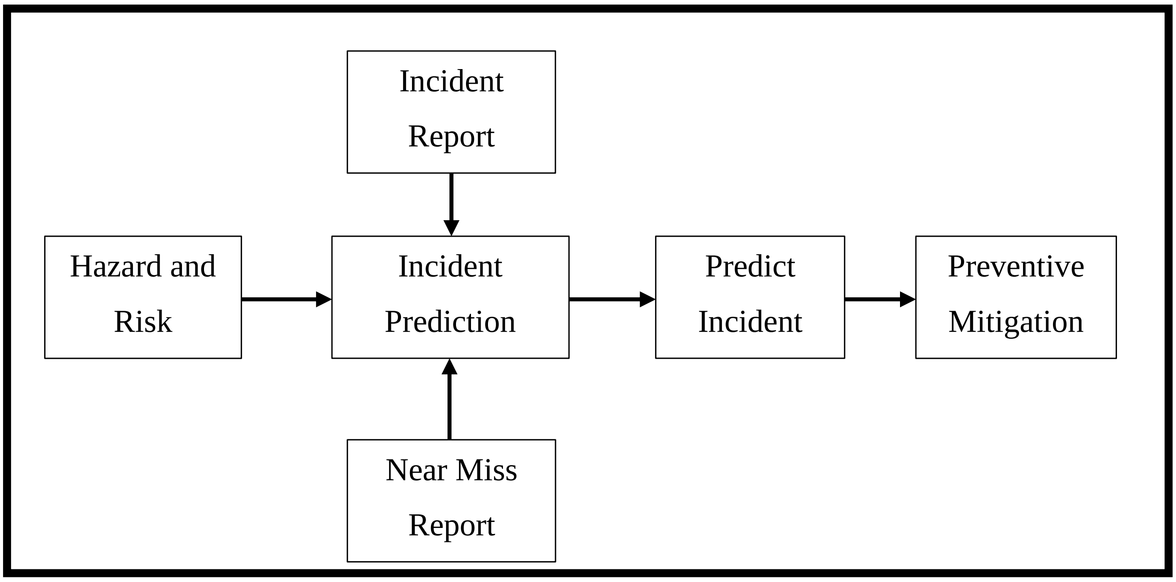

Figure 1: Incidents Prediction Process Flow

Figure 1 shows the methodology of the system development. This system is designed to be developed in 3 phases (refer to Figure 2) of research, which are:

Phase 1: Design a framework for the cloud-based intelligent platform
Phase 2: Development of cloud-based intelligent platform
Phase 3: Testing and validation

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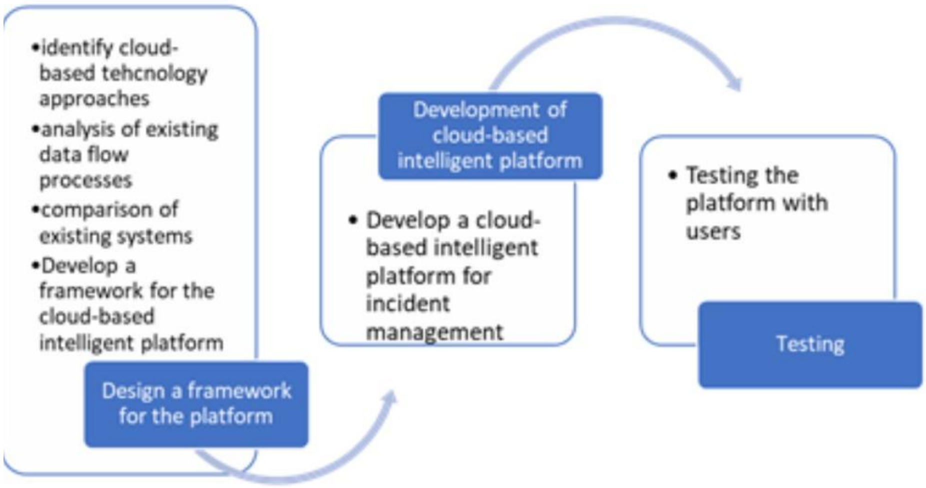

Figure 2: System Development Phases

Phase 1 Design A Framework For The Cloud-Based Intelligent Platform

In this phase, the general architecture of this system will be designed using a cloud-based system approach. An initial framework for the overall system is shown in Figure 3. Risk-related data will be collected from various locations, times, and sources. The data, which was previously collected manually by the relevant organizations' system administrator and safety officer, will be converted into digital form to allow for further analysis. A web interface can be used to enter this data into the cloud. The generic user, such as students or office workers, will be provided with a mobile app to enable them to report incidents or near-miss incidents that can be integrated into the system's overall database. Suitable data processing methodologies will also be determined based on case studies and the environment during project implementation. Shortcomings to existing projects in the same domain will also be identified so that the platform built is better and meets all the needs of users, and this platform can be fully functional.

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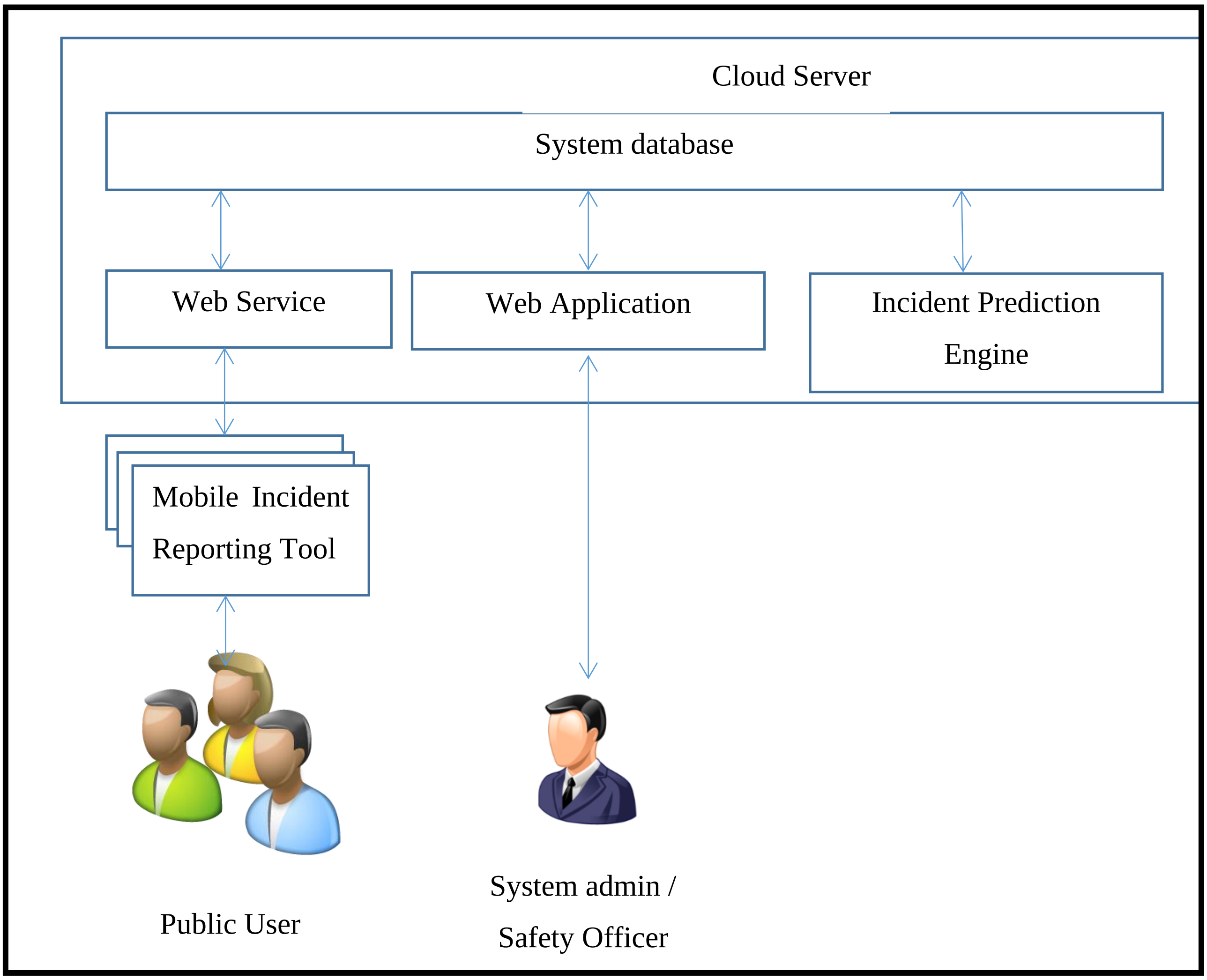

Figure 3: Architecture of the Proposed System

Our initial studies and engagement with the intended users (organisational management, safety officers, and managers) reveal the following required features and benefits of the system to the users:

User's Required Features:

- Inclusive stakeholder engagement and definition of the problem statement
- Collection of multiple data points, like historical data on injuries and near misses
- Predictive modelling using patterns configured in the machine learning algorithms
- Identification of correlations and patterns of factors in relation to the response variable
- Automatic recommendation for safety measures

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User's Required Benefits:

- Improve safety ratings and anticipate incident probabilities to improve safety measures
- Ability to predict incident probability using machine learning models
- Take precautionary actions based on online reports to reduce incidences
- Prevent the occurrence of physical incidents and injuries related to them

Phase 2: Development Of Cloud-Based Intelligent Platform

In this phase, developmental efforts will be executed to develop the system. The steps in Figure 4 show the execution plan for platform development:

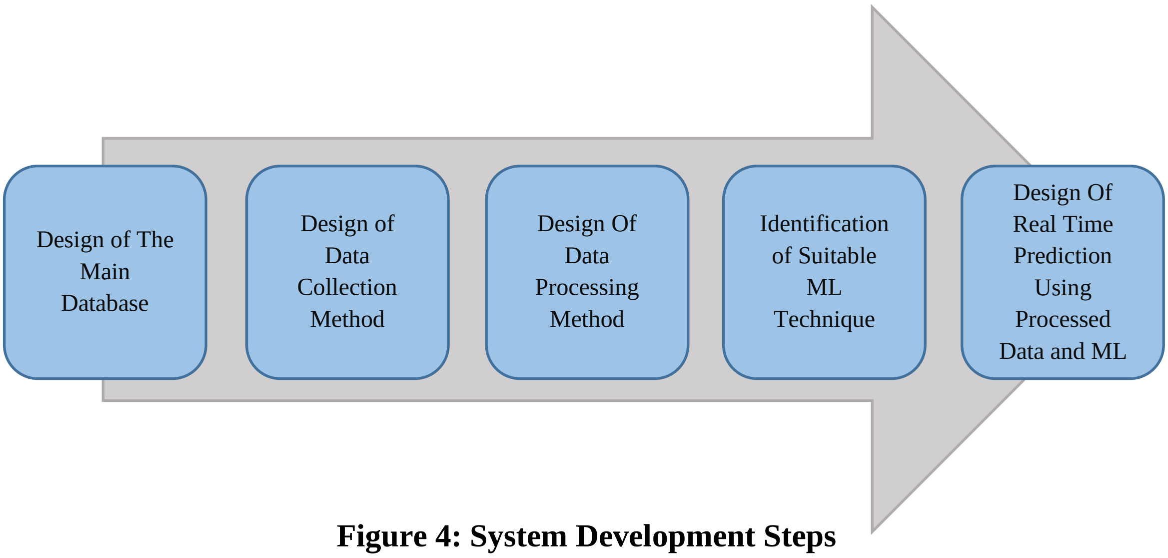

Figure 4: System Development Steps

One of the major concerns for design is code understandability among the various team members and the level of coding competency among the team members. As such, the design team opted for the use of the XOJO programming language for the initial design and prototype of the system due to its ease of use and flexibility compared to other web and mobile application development tools. The selected database engine is MariaDB, a well-known open-source relational database system.

Incident Prediction Strategy

For incident prediction method, our initial study reveals that the Similarity-Based Agglomerative Clustering (SBAC) is a popular method that can be used to predict the incident. The incident prediction engine will utilize this method in the initial version of the system. Other ML technique will be explored as we progressed further.

Based on our preliminary study, the architecture of the digital platform will consist of 5 phases as detailed in Figure 4:

1. The extraction of data: implement methods for extracting information that are tailored to the report's features. Sending to the central server (cloud): The next step is to send the recover data to the central server which is cloud.

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2. Data cleansing consists of deleting extraneous characters from data as well as segmenting it. Preprocessing entails cleaning and transforming data, which is a tedious and complex procedure due to the vast quantity of data and the poor quality of the data's information. In this step, numerous tasks must be completed, including data cleansing, user identification, and the identification of time, location, and occurrences.
3. Classify studied data according to existing groups. Similarity Based Agglomerative Clustering (SBAC) analysis was utilised to do clustering, which is the process of grouping items into groups whose members are similar in some way.
4. Data exploration and analysis: To forecast the occurrences, the K-Nearest-Neighbor (KNN) classification algorithm was selected.

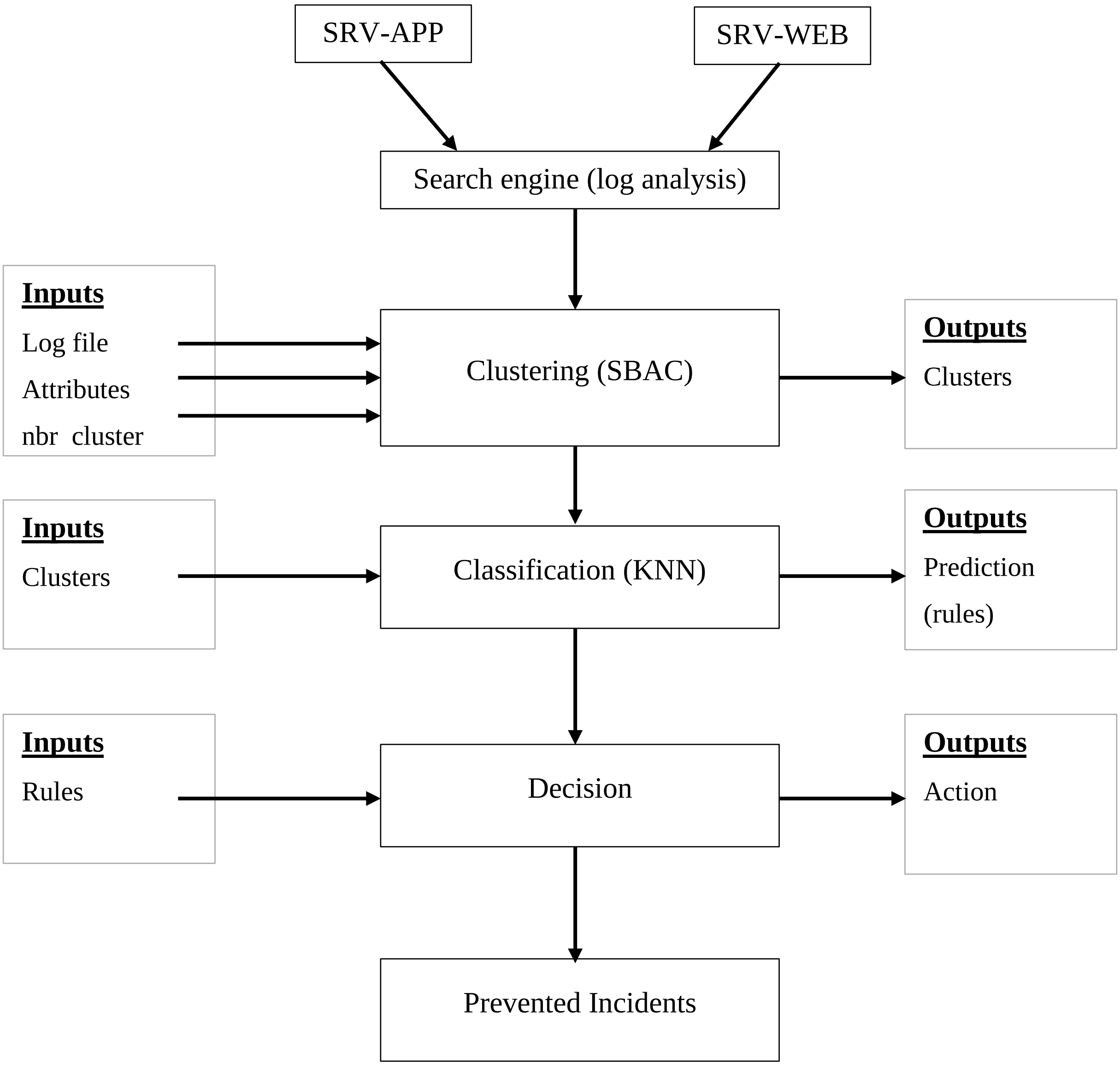

Figure 5: The Workflow For The Incident Prediction Of The System

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Clustering Analysis

The properties discovered by the Similarity Based Agglomerative Clustering (SBAC) algorithm to be particular to each of the clusters can be examined. Using feature dissimilarity, it is easy to see that for particular clusters, the more dissimilar a feature, the more unique it is.

The three main steps in this procedure are as follows:
1)deciding which incident features to cluster on; 2) calculating the degree of similarity between each pair of episodes; 3) creating a dendrogram using the SBAC hierarchical clustering algorithm, separating clusters using a minimum distance criterion, and counting the number of clusters in the dataset. using these figures, making a dendrogram, and then pruning it to get the right number of clusters.

Feature selection for incidents explains how events are classified using their features. To account for data trends, time and the distance to the closest intersection's continuous values were discretized.

Comparison analysis: A similarity measure between event pairs is computed when the incident's relevant features are chosen. Traditional clustering algorithms typically focus on either numeric valued data or nominal valued data rather than combining numeric and nominal data. Although every parameter in our case study is nominal, alternative implementations of this condition might need to take some numerical characteristics into account. We therefore utilise a similarity metric that works well with mixed typed data.

Similar Nominal Features: There are two options for nominal features: either the two objects have the same feature value or they have different feature values. The similarity score between two objects runs from 0 to 1 and is equal to 0 if their feature values are not identical (i.e., they are not at all similar). When two feature values are equivalent, the exact feature similarity score depends on how uncommon that value is in the population; the more common that value is, the less similar any pairs with that value are believed to be.

Similarity in Numeric Features: A somewhat different formula than for nominal features is utilised to calculate similarity for numerical features. When feature values are not equal, the traditional method is used to determine how similar two items are: the closer two objects' feature values are, the more similar they are.

Aggregation of every object similarity: In order to merge these individual feature similarities for a pair of objects into the overall similarities, we use Fisher's $\chi 2$ transformation to numerical features, assuming that each finding are given as the square of a standard normal deviation.

The number of Clusters is determined: To determine the appropriate level to cut the dendrogram at, we give each alternative grouping a weighted silhouette value. In a silhouette analysis, each incident's similarity to its assigned cluster is compared to its similarity to the subsequent most similar cluster. Let *a(i)* be the average dissimilarity of *i* with all data within the same cluster for each object *i* and let *b(i)* represent the lowest average dissimilarity of *I* to any cluster that *i* is not a member of. The silhouette of *i* is worth:

$$s(i)^n = \frac{b(i) - a(i)}{max\{a\ (i), b(i)\}}$$

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which generates silhouette values in the range $-1 \le s(i) \le 1$, a low number indicates that the incident is more comparable to objects in its neighbouring cluster, whilst a high value indicates that the incident is well matched with its assigned cluster. How well the objects are clustered is shown by finding the overall average silhouette score for each object:

$$\frac{1}{n} \sum_{i \in dataObjects} s(i),$$

where n is the total number of objects that are relevant for clustering. In order to simplify our groupings and favour cuts with fewer clusters, we add a complexity weight to the conventional silhouette analysis.

$$w.m + (\frac{1}{n} \sum_{i \in dataObjects} s(i)),$$

where *m* is the current cut's number of clusters and *w* is its weight. Applying this complexity-weighted silhouette grading to the dendrogram's groupings allows us to calculate the ideal number of clusters.

Analyzing individual clusters: It is possible to look at the characteristics that the Similarity Based Agglomerative Clustering (SBAC) algorithm determined to be unique to each of the clusters. It is simple to show that, for specific clusters, the more different a feature is, the more unique it is using feature dissimilarity.

Classification and Prediction

After performing a clustering analysis, this work employs a model system for event analysis, prediction, and interpretation utilising a KNN classification model. K-nearest neighbour classification is used in the above-described method to determine the event prediction model's best and most effective performance as well as the causes behind them. In order to anticipate the incident, K-Nearest Neighbor (KNN) is used, which proposes a new distance metric and weight determination method. The event data set compiled by the hazard management system itself served as the foundation for this KNN model's creation. Additionally, incident prediction and the optimal k value are optimised using a Matlab-based simulation. Finally, based on this simulation, an error analysis is done. The results of this classification procedure are then used to make the necessary decisions and to help resolve the current issue.

Phase 3: Testing And Validation

The incident reporting data from Universiti Kebangsaan Malaysia's Institute of IR4.0 is the first source of data used for design and testing (UKM). The system will be used in other UKM centres after being built and certified. Through user acceptance testing, the system's acceptance will be verified (UAT). The UAT's goal is to get feedback from system users who will really be utilising it to carry out related duties and who have experience with incident management procedures. Our UAT plan outlines the acceptance criteria in detail as well as a series of follow-up steps depending on test findings. To help the user accept system deliverables, an impartial guideline is given to them. Once the UAT is successful, the platform can be duplicated and

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used on a different cloud server to implement the system at a different institution. Figure 6 diagrams can serve as a representation of the replication process.

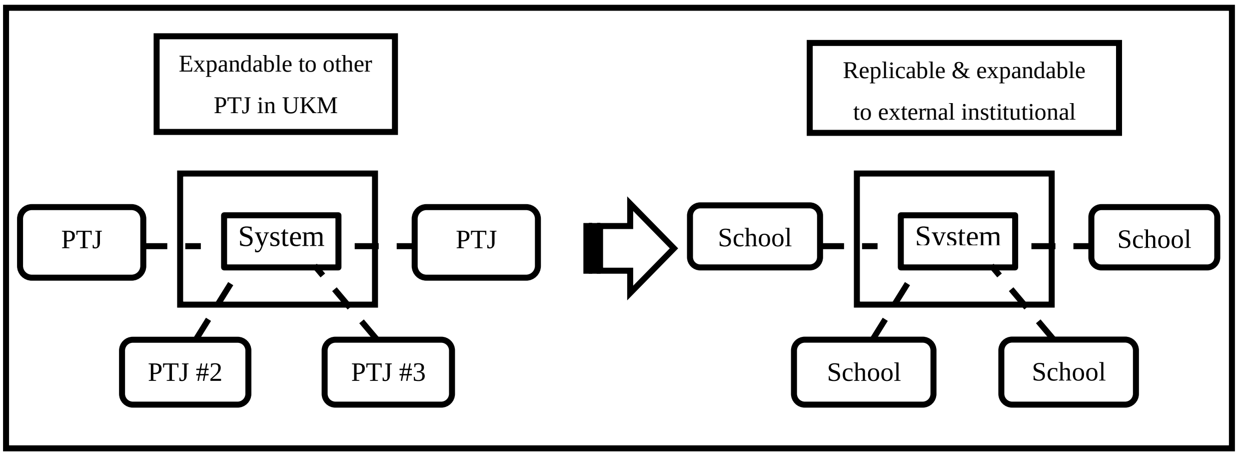

Figure 6: Replicability Of The System For Other Institutions

There are four criteria important in the proposed system which is related to the web application as per shows in Table 2. They are efficiency, errors, satisfaction and effectiveness. Besides, these four criteria also relate to tool testing.

Table 2: UAT Criteria

Criteria	Description
Efficiency	• Users accomplish their objectives and use the necessary resources to do so. • Including time spent studying and finishing tasks. • Information can be found by users more rapidly.
Errors	• Running duration allows for the lowest possible error rate.
Satisfaction	• The ease of use and good attitude of users toward the online application. • Attitude rating scales can be used to gauge user happiness. • The user finds the website to be satisfactory overall. • website navigation and site exploration being more pleasant
Effectiveness	• Users succeed in their objectives. • Including mistake rates and solution quality. • Overall system objectives are met

Our strategy for UAT clearly defines the acceptance criteria and a set of follow-up actions based on the test results. The user is provided with an objective guideline to assist in the acceptance of system deliverables.

Early Results For Initial Development And Implementation

The research team has developed a very early prototype of the system called HiPer (Hazard and Risk Identification and Prevention system). The early prototype serves to validate the risk and hazard management and incident and accident prediction algorithm. The research team is

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in the process of utilizing hazards to collect all necessary data. Validation of the feasibility and effectiveness of the system will be executed once the alpha prototype is running. Currently, the health and safety office of Universiti Kebangsaan Malaysia is also very interested in implementing the system, and further discussions are on the way to implement a beta prototype of this system that collects data from safety officers and managers from the whole university itself. The initial web module implementation for HiPer is shown in Figures 7–10. Figure 11 shows the prototype HiPer mobile applications that enables normal users to report near-missed incidents and hazards via their mobile devices.

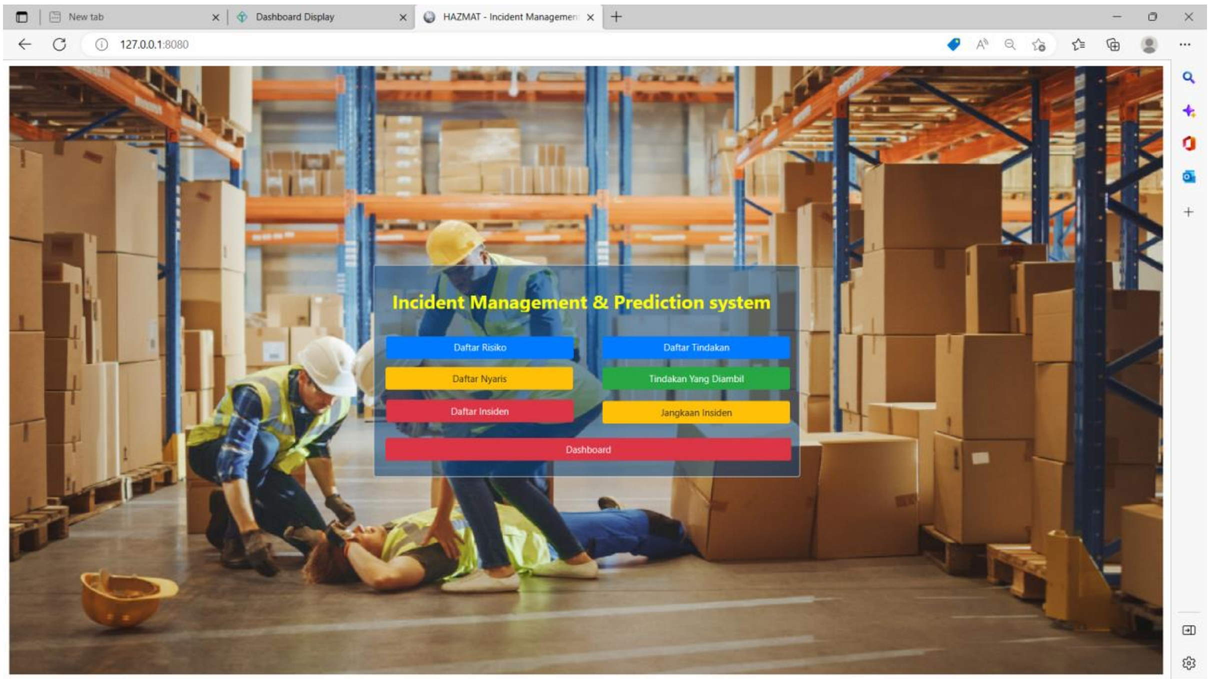

Figure 7: Landing Page for the Prototype of the System

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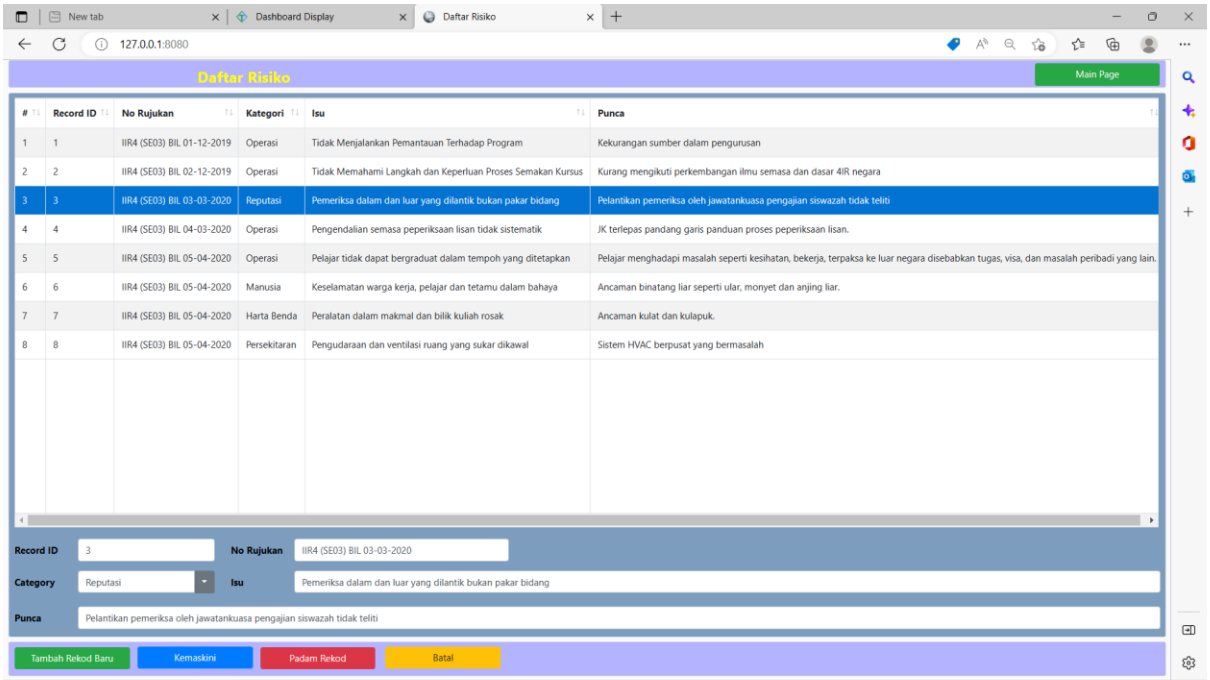

Figure 8: Risk Register View

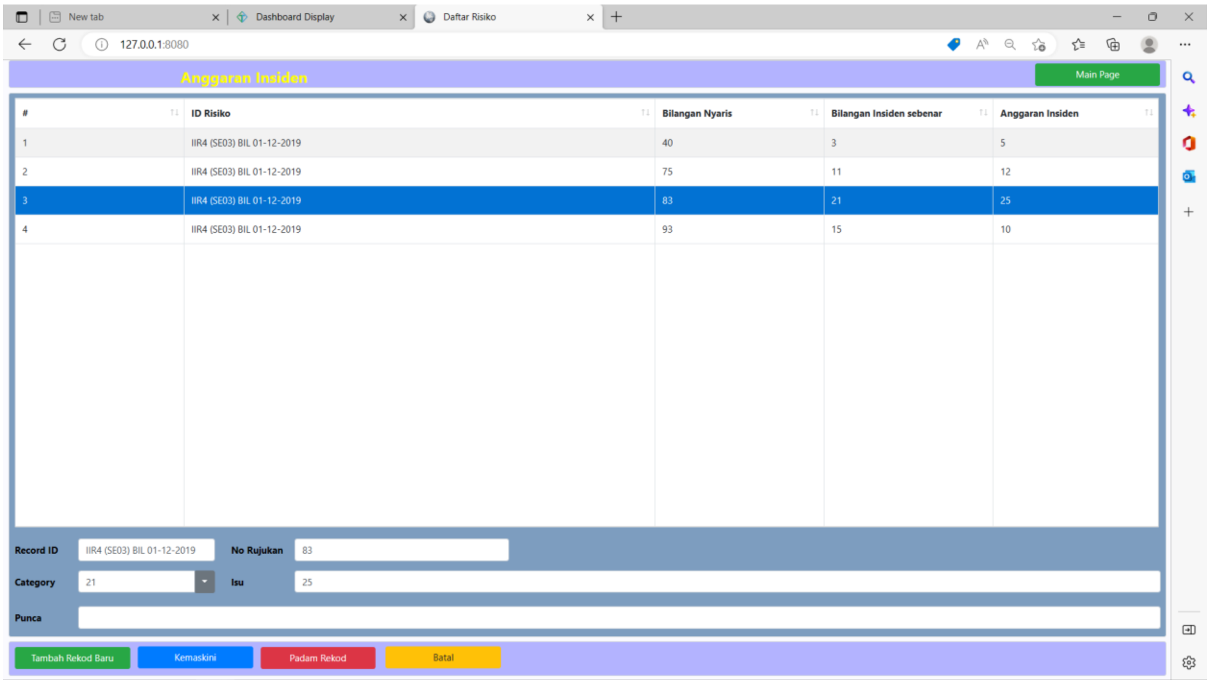

Figure 9: Predicted Incidents View

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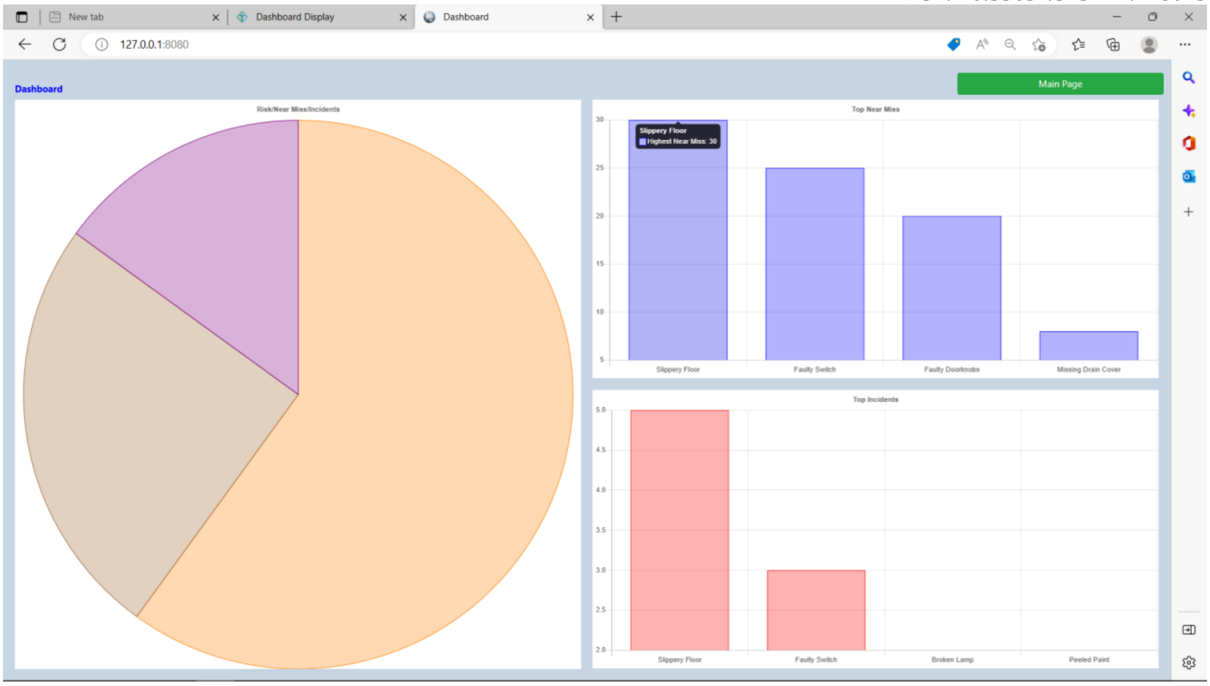

Figure 10: Dashboard Of The System Showing Risk Record And Incidents Occurred

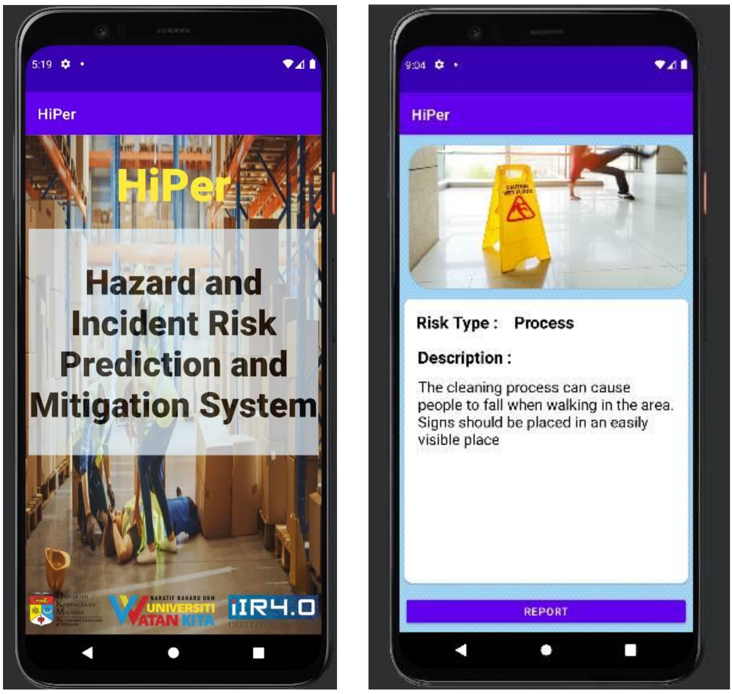

Figure 11: HiPer Mobile App (i) Welcome Screen (Left), User Reporting Screen (Right)

Summary

This paper has discussed the design strategy (architecture, process flow, development tools, ML method) for a replicable and extendable cloud-based intelligent system that can be implemented to enable systematic hazard and risk management and ultimately incident and accident prediction and mitigation for various type of institution and organization such

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universities, companies and schools. It combines several important functions. It does not only support hazard, risk, incident and accident management, but it also manipulates ML.

Specifically, SBAC algorithm to be particular to each of the clusters can be examined, using feature dissimilarity, it is easy to see that for particular clusters, the more dissimilar a feature, the more unique it is that enables the system to make predictions about the incidents that are likely to occur more accurately. For future work, the research team will improve the current prototype, implement the system in UKM and execute validation tests to see the viability and effectiveness of the proposed system.

References

Aburumman, M., Newnam, S., & Fildes, B. (2019). Evaluating the effectiveness of workplace interventions in improving safety culture: A systematic review. In *Safety Science* (Vol. 115, pp. 376–392). Elsevier B.V. https://doi.org/10.1016/j.ssci.2019.02.027

Anderson, A. I., Compton, D., & Mason, T. (2004). Managing in a dangerous world—the national incident management system. In *Engineering Management Journal* (Vol. 16, Issue 4, pp. 3-9).

Cortez, B., Carrera, B., Kim, Y. J., & Jung, J. Y. (2018). An architecture for emergency event prediction using LSTM recurrent neural networks. *Expert Systems with Applications*, *97*, 315–324. https://doi.org/10.1016/j.eswa.2017.12.037

CCOHS. 2022. *Hazard and Risk - General.* https://www.ccohs.ca/oshanswers/hsprograms/hazard_risk.html

Cushenan S. 2021. *What is the difference between a hazard and a risk.* 2021. https://www.ihasco.co.uk/blog/entry/3058/what-is-the-difference-between-a-hazard-and-a-risk

Dhamanti, I., Leggat, S., & Barraclough, S. (2020). Practical and cultural barriers to reporting incidents among health workers in Indonesian public hospitals. *Journal of Multidisciplinary Healthcare*, *13*, 351–359. https://doi.org/10.2147/JMDH.S240124

Government of Western Australia Department of Mines, Industry Regulation and Safety. (20220. *What is a hazard and what is risk*. https://www.dmp.wa.gov.au/Safety/What-is-a-hazard-and-what-is-4721.aspx#:~:text=A%20hazard%20is%20a%20source,or%20a%20combination%20of%20these.

Hajimohammadi, N., Sadeghi, T., & Hosseini, S. H. (2018). Evaluating the Effect of an Educational Intervention for Nursing Managers on the Rate of Incidents Reported at University Hospitals of Iran. *Hospital Topics*, *96*(2), 47–53. https://doi.org/10.1080/00185868.2017.1411172

Hu, L., Li, J., Nie, L., Li, X.-L., & Shao, C. (2017). *What Happens Next? Future Subevent Prediction Using a Contextual Hierarchical LSTM Model*. Www.Aaai.Org.

HSE STUDY GUIDE (2020). *What is Hazard/Risk/Accident/Incident/Near miss in hindi|difference in hazard/risk/accident/incident.* Video Youtube. https://www.youtube.com/watch?v=8X6HgBPm9Cg

HSE.*Accidents and investigations.* https://www.hse.gov.uk/toolbox/managing/accidents.htm#:~:text=accident%3A%20an%20event%20that%20results,miss%20will%20include%20dangerous%20occurrences) https://www.osha.gov/sites/default/files/2018-11/fy10_sh-20839-10_circle_chart.pdf

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Karkošková, S. (2018). Towards Cloud Computing Management model based on ITIL processes. *ACM International Conference Proceeding Series*, 1–5. https://doi.org/10.1145/3278252.3278265

Luburić, R. (2019). A Model of Crisis Prevention (Based on managing change, quality management and risk management). *Journal of Central Banking Theory and Practice*, *8*(2), 33–49. https://doi.org/10.2478/jcbtp-2019-0012

OSH WIKI. Accidents and incidents. https://oshwiki.eu/wiki/Accidents_and_incidents

Pidgeon, N. F. (1991). Safety Culture and Risk Management in Organizations. *Journal of Cross-Cultural Psychology*, *22*(1), 129–140. https://doi.org/10.1177/0022022191221009

QUE, B. , O. M. , J. J. , H. J. , W. J. , M. P. , . . . & C. J. (2018). Effect of network system desktop exercise on sudden poisoning incidents. *China Occupational Medicine*, 46–50

Safety Culture (2022), Incident Management: How to proactively manage incidents and maintain continuous operations https://safetyculture.com/topics/incident-management/

Turner, B. A. (2019). The development of a safety culture. *Risk Management*, 397–399.

Varallo, F. R., Passos, A. C., de Nadai, T. R., & Mastroianni, P. D. C. (2018). Incidents reporting: barriers and strategies to promote safety culture*. *Revista Da Escola de Enfermagem*, *52*. https://doi.org/10.1590/S1980-220X2017026403346

Wang, K., Zhao, S., & Jackson, E. (2019). Functional forms of the negative binomial models in safety performance functions for rural two-lane intersections. *Accident Analysis and Prevention*, *124*, 193–201. https://doi.org/10.1016/j.aap.2019.01.015