" نموذج التنبؤ بحوادث المركبات للمدن الذكية باستخدام الحوسبة الطرفية"

Vehicle Accident Prediction Model for Smart Cities Using Edge Computing

إعداد

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دكتوراه هندسة البرمجيات بكليات عنيزة في المملكة العربية السعودية

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Abstract

Development of Edge Computing and Internet of Things (IoT) leads to get the great benefits of smart cities. Increasing number of vehicles has brought focus on cars and passengers safety and city to vehicle (c2v) communication. This paper focuses on proposing a model for earlier prediction of vehicular possible hazards. The proposed system uses smart city infrastructure such as sensors and high resolution cameras to capture any possible incident and analyze these data for any possible accidents. Any hazard occurrence leads to send a voice alert to the car driver (owner) telling to perform some steps that avoid him many real accident and save his and others life.

Keywords: *Edge Computing*, *IoT, smart city, GPS,GSM, image processing.*

الملخص

إن التطور الكثير في نظم الحوسبة المتقدمة ونظم إنترنت الأشياء يؤدي إلى الحصول على فوائد كبيرة من المدن الذكية. وقد أدى تزايد عدد المركبات إلى التركيز على سلامة السيارات والركاب والتواصل فيما بين المدينة والمركبة (نظام مدينة – مركبة). يركز هذا البحث على اقتراح نموذج للإنذار المبكر للمخاطر المحتملة للمركبات بحيث يستخدم البنى التحتية للمدينة الذكية مثل أجهزة الاستشعار والكاميرات عالية الدقة لالتقاط أي حادث محتمل وتحليل هذه البيانات لأي حوادث محتملة. فبظهور أي خطر فإن ذلك يؤدي إلى إرسال تنبيه صوتي إلى سائق السيارة (الشخص المسجل في النظام) ليعلمه بضرورة تنفيذ بعض الخطوات التي تجنبه العديد من الحوادث الحقيقية وإنقاذ حياته وحياة الآخرين.

كلمات البحث: نظم الحوسبة المتقدمة، إنترنت الأشياء، المدينة الذكية ، نظام تحديد المواقع ، جي إس إم ، معالجة الصور.

1: Introduction

We regularly see that when an accident happens the car driver has no previous knowledge about the reason of that accident (Mohanta et al. 2021). Sometimes it happens that he comes to know the reason for the accident but the chance to avoid it is very small due to late reaction. Most of the cases happen where the driver has no idea about what is happening around him which may even lead to death of the people met in accident. Also there is no systems in automobiles to recognize the incidents such as flames or smoke in the vehicle immediately and alert them while driving their vehicle (Shetgaonkar et al. 2015). The main motivation behind forthcoming with this system is to enhance the safety features for vehicles and therefore contributes in providing on minimizing accidents occurrence which of course affect people and properties. The main function of the proposed system is:

- To early detect a possible accident and generate an automatic voice alert to the car owner (driver) account telling him what to do.
- To send an alert to the emergency services containing the location of vehicle and the type of the possible accident which can ensure that there is no delay in informing so they can take many actions which can save people life.
- To detect the several possible reasons for accidents such as types such flames, smoke, punchers, opened doors or any part (children) goes out of the car. Whenever the cam detects any of the previous cases the user will be informed about it. Other optional functions of the proposed system are:

1. Monitoring location and speed of the vehicle
2. Acknowledgement of alert delivery.

These optional features will help the driver of the vehicle at the time of expected accident that he got his mobile phone with him at the same place and can also help the driver in case his application is not responding for any reason, an alert will be forwarded through the smart city information center (SCIC) to the emergency center with a report of the case so they can decide the suitable action (Dey et al.2019). This system has the ability to predict accidents depending basically on the high resolution cameras that will be distributed in Neom smart city. The city was suggested and presented first time at the Future Investment Initiative conference in Riyadh, on October 2017, by the Saudi Crown Prince Mohammed bin Salman (Madakam et. al 2020). It also presents high standard of new urbanism, design, architecture, as well as great technology principles.

2. Methodology

In this paper we develop a model for detecting accidents before they happen. Figure 1 illustrates the behavior of the model using UML language sequence diagram.

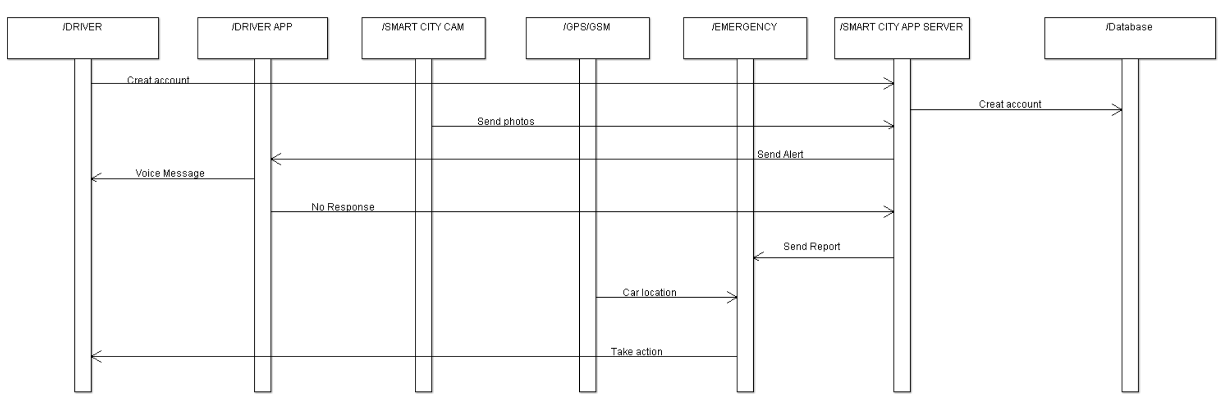

Fig 1: UML Sequence Diagram for the Proposed System

The proposed system involves different modules which will be interconnected to Neom city application.

- GSM module: The road GSM connects high definition cameras to the internet using the GPRS wireless network. It is recommended to these cams using an operator SIM card which offer GPRS coverage or nearby high speed Wi-Fi networks to get connected to the internet.
- GPS module: The GPS module for city road camera and for application user is a small electronic circuit which permit to connect to the network and send the current car location, once by the road GPS sensor and another time by the user sensor to conform the actual location of the car as the actual location of the driver's mobile (This useful if he doesn't have his mobile with him in the time of accident prediction).

3. Model Description

Whenever a reason for an accident arises, such as a children who is out of the car window or a smoke or fire or even car tiers or exceeding speed limit is detected the particular camera and GPS sensors send information about the case into the city application server. The application on the server side analyze the received photos and information and decides whether the case exceeds the threshold level of each case. On the other hand, the road GPS sensor sends the car location while the cam sends the suspected states and the car plate for recognizing the identity of the car driver. In parallel with that, the driver's application sends the current location so the application of the smart city can determine whether the mobile phone which have the user application is inside the car or somewhere else. If the mobile is not nearby, then the system sends alert message to the emergency center with car situation and the with the recommended procedures that could be followed.

4. Implementation And Results

The figure below illustrates the proposed system components such as sensors, cams, users applications and GSM and GPS modules connected to the smart city information center.

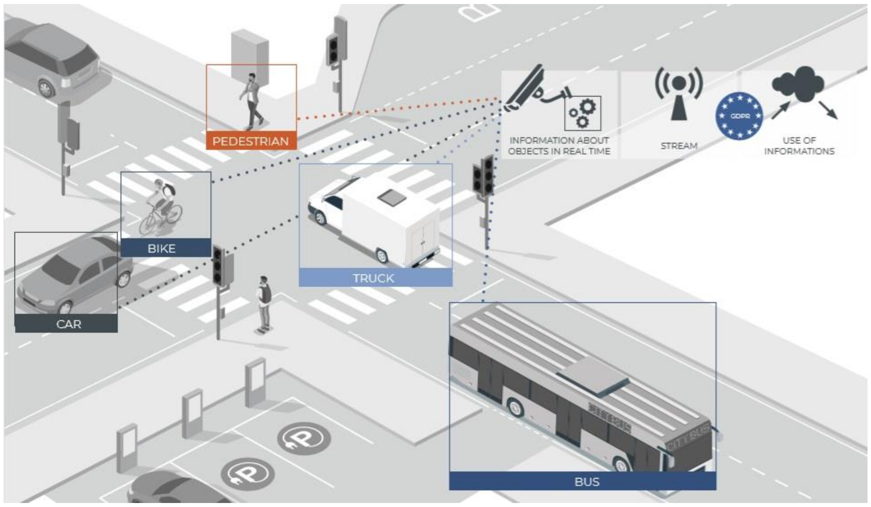

Figure2: Components Of The Proposed System

To test and verify the correctness of the proposed system; Promela (Process or Protocol Meta Language) language (the input language for spin model checker) code that represents the model is used to test the behavior of all model. The figure below shows the achieved results while testing the implemented model of the proposed real-time system. SPIN checks some properties of the mapped model by figuring out any traces that could lead to the "undesired" state. If such a trace is not there, then the property is satisfied (M. Machin et al. 2015). There for SPIN model checker is used for evaluating assertions that could be placed between any two statements in the state space of the generated model (Hegde, et al. 2012). If a calculation which causes a false assertion is found, then that could mean either the implementation is incorrect, or the assertion doesn't express a correctness property (Hegde, et al. 2012). The evaluation of the model behavior which is shown in figure 1 is carried on in the simulation process with true or false expression for exact statement. If a statements is progressed correctly, then the model checker will continue to the next statement, but if it is not continued correctly then the program will be terminated and show a *trail* with the number of the errors (Samanta, et al. 2008). LTL (i.e. Linear Tree Logic) is used sometimes to check definite properties of the system like absence of deadlocks, safety, liveliness (Huth and Ryan, 2007).

The verification process which's used in this work was successfully used in previously by Alnajim (2015) and Alnajim and Alrawashdeh (2016). This research focuses on the formal verification of an IoT model using SPIN model checker which can verify for vulnerabilities in the model. Each part of the model is considered as a different process. These processes are recognized in Promela that reads the processes behavior. The model is contains some entities that connect to each other using global channels. Therefore, the model is mapped into UML (Unified Modeling Language) sequence diagram using a CASE tool called ArgoUML. We use a tool called Hugo/RT to conver the generated model into Promela code using.Then we combined some LTL properties with code in order to use it for verifying the timing of the model responses as shown in table 1. This code is written as followed:

```
proctype E-learning (){
printf("initiating SmartCityAccidentPrediction Process...\n");
DisplayMenuState:
UserInterface!DISPLAY_Options->
printf("SmartCityAccidentPrediction: connected to Core switch...\n");
printf("SmartCityAccidentPrediction  Process: Protected by Firewall...\n");
goto Securitysystem;
printf("initiating  E-remoteaccess  Process...\n");
UserInterface!acident prediction system->
do:: MeasureAlertSending
   :: validateGeneratedAlert
printf("SmartCityAccidentPrediction Process: AccessToDdatabase...\n");
printf("SmartCityAccidentPrediction Process: AccessToInternet...\n");
printf("SmartCityAccidentPrediction: SmartCityAccidentPrediction...\n");
Od::
goto EmergencySystem;
```

```
do:: EvaluateResponces
   :: ensureRoles_Privilege
printf("SmartCityAccidentPrediction Process: AccessToDdatabase...\n");
printf("SmartCityAccidentPrediction Process: AccessToInternet...\n");
printf("SmartCityAccidentPrediction Process: AccessTo SmartCityCameras...\n");
od::
  }
```

SPIN verification is run to check for deadlock and unexecuted code in the *Smart* City Accident Prediction model. As shown Figure 3, SPIN did not report any “invalid end state”; since it did not find any deadlock in the model. Furthermore, there is no errors in codes, as all processes have zero unreached states.

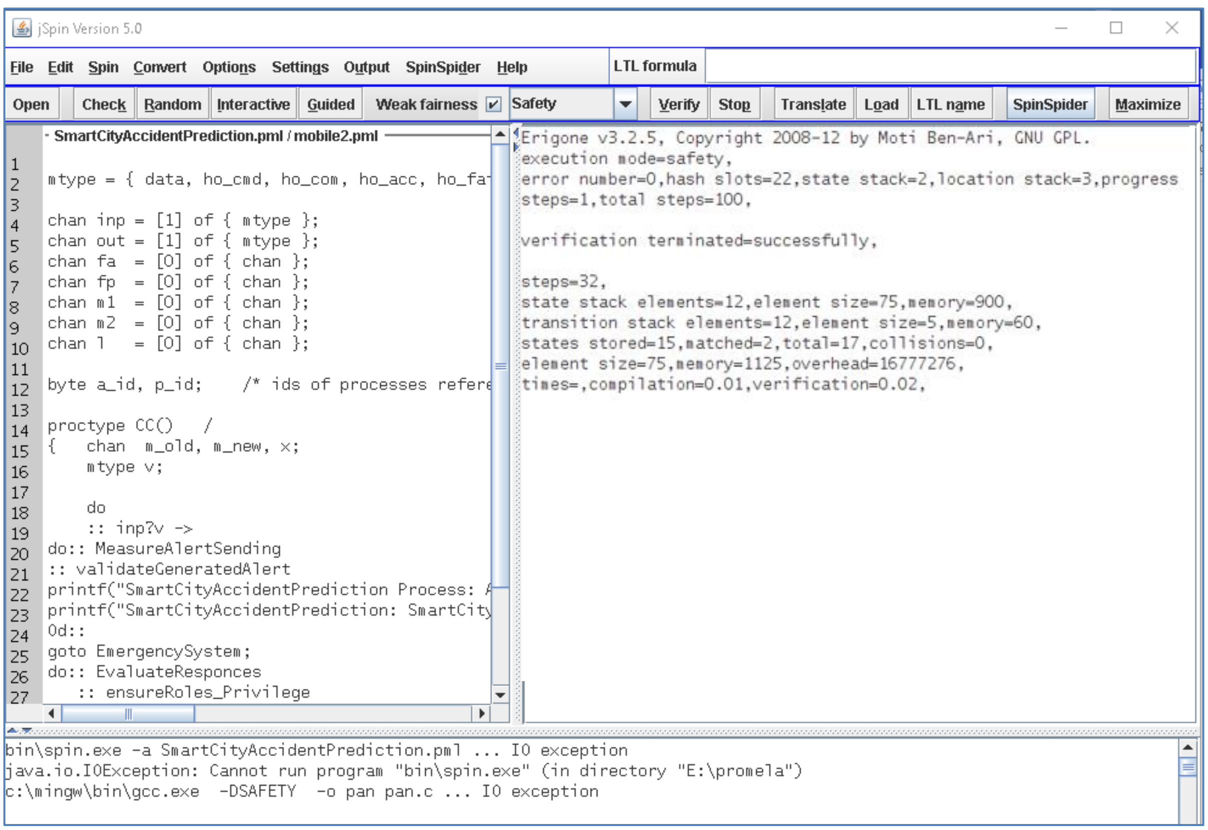

Fig 3: SPIN model checker run result

The properties of the states are checked with LTL properties using SPIN as. The checking result showed that the IoT accident predicting model has passed these properties in the validation process. In summary, SPIN model checker is used in this research to validate that the model has no deadlocks or unreachable states. This research has achieved its goal and expectations by mapping the model and formally verifying the E-learning model. The research has successfully coded the model using PROMELA language and validated it using SPIN Model Checker. The research performed the verification by checking deadlock and unreachable states. It is found that deadlocks and unreachability states do not exist in the model. For future work, another model verifier such as CPAchecker can be used and run over the model to achieve a strong result about the correctness of the IoT accident prediction model behavior.

5. Conclusion and Future Work

The proposed model for IoT accident predicting system can assure that it can be an important assistance in building intelligent smart city transport systems where the system can be used by the owners of the Bus and Taxi companies and owners to track their vehicles by getting clear reports about the possibility of making accident and make auto evaluation for them. As a future work, we suggest to implement the system in all cities of Saudi Arabia as well as all over the world.

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