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Driving Safely in Smart Cars in a Smart Road Environment

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ABSTRACT :- *Smart cars are promising application domain for ubiquitous computing. Context-awareness is the key features of a smart car for safer and easier driving. Context recognition is important support for a smart car to avoid accidents proactively. Regardless of many industrial innovations and academic progresses, there is still today a lack of fully context-aware smart cars. This paper presents an overview of the related works on different smart cars and smart road environment systems. The nature of context awareness in smart cars and road environment is also presented. Moreover, the term paper proposes a hierarchical context model for description of the complex driving environment. Smart cars continuously connectivity and sharing information under intelligent mobility has been put forward. A smart car prototype including software platform and hardware requirements is built to provide the running environment for the context model and application. Performance metric shows the accuracy of context situation recognition.*

KEYWORDS :- *Context-aware, seamless connectivity, smart car, smart road, vehicle-to-vehicle communication (VVC), vehicle-to-infrastructure communication (VIC).*

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I. INTRODUCTION

Cars have become part of people's lives. These automobiles bring convenience and ease to our lives for easy mobility from places to other places; go work, parents bring kids to school without getting late, in emergency situations where a transport mean is needed to go urgently to hospital, for vacation trips and other daily activities. However, many problems also arise, such as traffic congestions and accidents. A smart car aims at assisting its driver with easier driving, less workload and less chance of getting injured [1]. Smart car must be aware of the environment, which means sensing and recognizing the context around the car and the driver. Context-awareness is the key feature of a smart car for safer and easier driving.

The tomorrow's vision of driving in a city which can interact, act and respond to the driver's needs would be far from reality some 20 years back. Today, in the 21st century, such smart road environments are already being built around the world. Smart car must be able to sense, analyze, predict and react to the road environment. In a near future, everything in a city, from the road directions, roads' lighting, traffic signaling will be connected in a network. Smart cars or vehicles embedded with artificial intelligence will allow self-driving; finding space parking on its own intelligence without driver maneuvering on the steering.

Obtaining such broad view of the environments of both roads and cars is only possible through collaboration between the infrastructures and car's sensing abilities. The aims are to develop and test the technology that will enable such cooperation, which will increase the amount of information available to driver. Moreover, by combining quality data from roadside sensors and data sent directly from vehicles in vicinity, advance knowledge can be gained about potential safety risks. This research paper focuses on how to build a context-aware smart car.

The remainder of this paper is organized as follows. Section 2 introduces to related works on smart cars and smart roads. The evaluation and problems of the existing works is given in Section 3. Nature of Context-awareness in Smart Cars and Road environments is presented in Section 4. Section 5 shows the proposed system of smart cars and Section 6 presents the evaluation performance of the smart cars system and Section 7 is about experimentation of accuracy of context situation recognition. The conclusion is given in Section 8.

II. RELATED WORKS

In the past decades, lots of technologies have been developed in the field of intelligent transportation system (ITS) (Wang et al.., 2006) [2] and the advanced driver assistant system (ADAS) (Küçükay and Bergholz, 2004) [3]. However, current smart cars are not in actual fact context-aware. Only a few types of the information of road environments, referred as contexts, are utilized. The weaknesses are that most of current smart cars lack complex reasoning which limit the smart car's ability of assisting the driving task efficiently and safely. The following describes major progress, recent advances, ongoing researches, and research projects being carried out in this field.

Communication and cooperation – At the Intelligent Transport System test site, Toyota is testing smart cars that talk to each other and to the roads on the communication frequency of 700MHz band with the main goal of reducing traffic accidents. According to Toyota, the site is equipped with a road-to-vehicles communication system, consists of a vehicle detection system, a pedestrian detection system, a course monitoring system, traffic signal and control devices [4]. The Vehicle-Infrastructure Cooperative Systems support driving, and aim to avoid traffic accident by notifying drivers of the context captured through communication between the vehicles and sensors installed on the road, or among vehicles. Since 2009, Toyota has commercialized some functions of the system after participating in some providing tests held by the relevant governmental agencies and automotive industries [5]. (a) The DSSS function, Driving Safely Support Systems, are designed to focus on road environment, to convey information/context about vicinity vehicles, motorcycles, and pedestrians that are outside the visual range of the drivers, as well as, traffic control information such as traffic signals, traffic state (congestion or light traffic). The sage driving operation of the system started in operation in 2011. (b) Efforts for communication System between Vehicles and Pedestrians or Among Vehicles. The new generation of vehicle Infrastructure Cooperative System uses direct communication between vehicles and pedestrians or among vehicles for continuous information exchange in order to prevent frontal collision accidents at intersections difficult for drivers to see. Toyota participates actively in developing the systems to contribute to the environment reform and to improvement of traffic flows [6]. To motivate the description of the communication and cooperation system, an example of smart cars talking to each other and to the road is given as follow; smart cars at Intelligent Transport System site capture real-time context from sensors and transmitters installed on streets to reduce risk of accidents in situations such as missing a red traffic light, cars advancing from blind spots and pedestrians crossing the street. The system also tests that smart cars talk to each other. In a test drive, the presence of a pedestrian triggered a beeping sound in the car and a picture of a person popped up on the screen in front of the driver. Picture of an arrow popped at intersection, indicating an approaching vehicle. The system outputs a voice message “It’s a red light”, if the driver was about to ignore a red light.

Driver assistant system – Many novel ideas have been implemented in newest series of concept cars by automobile manufacturers. (a) BMW’s ConnectedDrive includes BMW Assist, BMW Online and driver assistance systems, supporting lane change warning and parking assistant (Hoch et al.., 2007) [7]. (b) Mercedes-Benz is developing an intelligent driver assistance system that utilizes stereo cameras and radar sensors to monitor surroundings around the car (Benz, 2007) [8]. (c) Advance pre-collision system, dynamic driving, electronic brake assistance system and park-assistance systems for active safety are being installed by Lexus on its LS-series (Lexus, 2007) [9]. (d) Furthermore, Toyota announced two newly developed safely system; an intelligent Clearance Sonar and Drive-start Control, target to eliminate traffic problems (congestions and accidents).

Collision avoidance system – With pedestrian fatalities taking an unexpected rise in recent years, automakers are looking for ways to not only reduce the death toll but quite literally steer clear of pedestrians in the first place [10]. The automobile safety system is designed to reduce the severity of an accident. Usually uses radar and laser or camera sensors to detect an imminent crash, and provide an warning to the driver when there is an imminent collision or take action autonomously without any driver input (by braking or steering or both). (a) Ford’s Collision Warning with brake Support was introduced in 2009 on the Lincoln MKS and MKT and Ford Taurus [11]. This system provides a warning through a Head Up Display that visually resembles brake lamps. If the driver does not react, the system pre-charges the brakes and increases the brake assist sensitivity to maximize driver braking performance. Ultimately, the smart vehicle will automatically attempt to steer away from the pedestrian [12]. Furthermore, a new Pre-collision system by Toyota includes collision avoidance assistance that is effective in high-speed collisions and more than 90% of speed ranges in rear-end collisions [13].

Vehicular ad hoc networks (VANETs) – VANETs have emerged as an application of mobile ad hoc networks (MANETs), which use dedicated short-range communication (DSRC) to allow vehicles in close proximity to communicate with each other or to communicate with roadside equipment. Applying wireless access technology in vehicular environments has led to improvement of road safety and a reduction in the number of fatalities caused by road accidents through development of road safety applications and ease of information sharing between moving vehicles regarding the road.

Intelligent vehicular ad-hoc network (InVANET) integrates multiples networking technologies such as Wi-Fi IEEE 802.11p, WAVE IEEE 1609, WiMAX IEEE 802.16, Bluetooth, IRA and ZigBee [14]. VANETs are expected to implement technologies such as dedicated short-range communication which is a type of Wi-Fi. Other candidate wireless technologies are cellular and satellite. As promoted in intelligent transportation systems (ITS), vehicles talk with each other via inter-vehicle communication (IVC) as well as roadside base stations via roadside-to vehicle communication (RVC). Providing IVC and RVC can considerably improve traffic safety and comfort of driving and travelling. InVANET can be used as part of automotive electronics, which identifies an optimally minimal path for navigation with minimal traffic intensity. The system can also serve as a city guide to locate and identify landmarks in a new city.

Currently there is ongoing research in the field on InVANETs for several scenarios. The main interest is in applications systems for traffic scenarios, mobile phone systems and sensor networks. Recent research has focused on topology related problems such as range optimization, routing mechanisms, or address traceability. New interest is emerging for green InVANETs, in other words, minimal power consumption for sensor networks [15].

Driver behaviour recognition – The driver plays an important role in a smart car. VANETs also focus on developing a novel and nonintrusive driver behavior system using a context-aware system, to detect abnormal behaviours exhibited by drivers and to warn other vehicles on the road to prevent accident from happening [16].

Vigorous efforts are under way today to research and develop partially or fully automated driver behavior systems, such as those for headway distance control of lane keeping control by making use of Intelligent Transportation System (ITS) technologies [17]. Machine learning and dynamical graphical models, such as HMM (Oliver and Pentland, 2000) [18], Gaussian Mixture Modeling (GMM) (Miyajima et al., 2007) [19] and the Bayesian network (Kumagai and Akamatsu, 2006) [20], can be applied for modeling and recognizing drivers behaviours. Several researches have examined the development or driver monitoring and detection systems using these models above.

Most researches focused on building a context-aware smart car by developing a hierarchical model that is able to collect contextual information (Behaviours: normal, drunk, fatigue, reckless and other uncertain context), reason about and react, to contextual information about the driver, vehicle and environment, in order to provide a safe and comfortable driving environment [21]. D. Sandberg and M. Wahde proposed a system for drowsy driver detection in real time driving by collecting information about the driver's behaviour such as speed of the vehicle, the vehicle's lateral position, yawing angle, steering wheel angle and the vehicle's lane position. Their system uses artificial neural networks to combine different indications of drowsiness and to predict whether a driver is drowsy and issue a warning if required [22]. H. Ueno, M. Kaneda, and M. Tsukino developed a non-contact system to prevent driver drowsiness by detecting the eyes of the driver and checking whether they are opened or closed using a CCD camera. The system is based on capturing the face of the driver and using image processing techniques to check if the driver's eyes are closed for long intervals. If so, the system issues a warning to driver [23].

Driver-Vehicle Interface – The Adaptive Integrated Driver-Vehicle Interface (AIDE) project tries to maximize the efficiency and safety of advanced driver assistance systems, while minimizing the workload and distraction imposed by in-vehicle information systems (Kutila et al., 2007) [24]. The Communication Multimedia Unit Inside Car (COMUNICAR) project aims at designing an easy-to-use on-vehicles multimedia human-machine interface. An information manager collects the feedback information and estimates the driver's workload according to the current driving and environment situation (Bellotti et al., 2005) [25].

Smart Roads – In U.S, the Federal, State and local governments are investing about tens of billions dollars into nation's infrastructure to make the roads, bridges and other assets much more intelligent. This vision known as smart road or infrastructure promises to make the nation more productive and competitive, while helping the environment and saving lives.

"The goal is not just funding projects for short-term job gains, it should be to create systems that are intelligent and improve productivity in the long run", says Paul Feenstra, vice president of government affairs at the Intelligent Transportation Society of America, a group that promotes smart-road technologies. (a) Smart Bridges, network of sensors at critical points is used for continuous electronic monitoring of bridge structures; these devices can deliver data about the behaviour of the bridges under heavy traffic, in high winds or other conditions. Also, hidden spots potentially serious problems such as hidden cracks, erosion after floods, long before they might be apparent to a human inspector can be detected. "Automatic detection can make the difference between a major disaster, a costly retrofit or a minor retrofit", says Mohammed Ettouney, a principal in Weidlinger Associates Inc., a New York engineering firm [26]. (b) Virginia Smart Road is a unique full-scale research facility managed by the Virginia Tech Transportation Institute (VTTI), is currently working on lighting system project. The Smart Road is equipped with variable lighting, multiple luminaire heads and poles mounted for test simulations like crosswalks for pedestrians, vehicles approaching pole lighting as needed. To illustrate this scenario; suppose a person driving at night on a winding road on a snowy weather condition and poor road visibility, approaching a curve way, the person feels safe knowing the smart car is equipped with obstacle detection sensors and lighting street detectors that will warn the driver to stop or provide additional safety measures like making street lighting more brighter. The driver feels more confident and comfort [27].

III. EVALUATION OF EXISTING SYSTEMS

Most of the works listed above is not fully context-aware. The reasoning of contexts for further analysis is not put enough emphasis on. Most current researches focus special practical technologies such as communication, sensing and driver assistance. These limit smart cars to be cars with certain accessories. There is a lack of a common consensus and comprehensive understanding of smart cars in a holistic view.

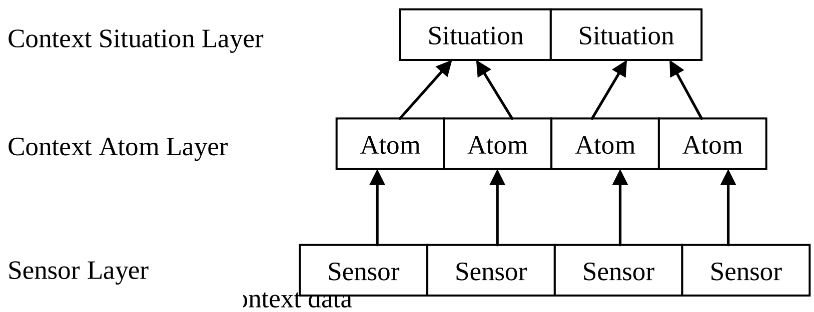
Moreover, the driver behaviour detection system as presented in Section2 focus on the detection of driver's status (drunk, affected by fatigue, drowsy) by monitoring the driver or the vehicle and issuing warning messages to the driver to prevent road accidents. Whilst these systems have achieved good results in terms of improving road safety, they are limited to alerting the driver or controlling the vehicle itself. The major concern in term of context-awareness is these systems currently have not considered the behaviour of the driver as a high level context (uncertain context).

This study attempts to build a smart car from the viewpoint of context-awareness. All the entities of a context captured by the drivers and in driving environment will be preprocessed and defined. Reasoning plays an important role in complex situation analysis. Leading context-awareness to a higher-level of reasoning will allow development of different services and applications in smart cars without much modification to the current architecture.

IV. NATURE OF CONTEXT-AWARENESS IN SMART CARS AND ROADS

Context recognition includes raw data collection and preprocessing, feature extracting and selection, and recognition method. (a) Raw data from various sensors are captured and preprocessing, includes noise removal, data calibration and transforming of data distributions. (b) Feature extraction and selection, features extracted from sensor signals referred as context atoms are classified in hierarchical models enables high performance. (c) Context recognition method, capturing context atoms from several sources at an instant of time has similar aspects to sensor fusion. Bayesian classifier and neural network are commonly used methods.

Context is any information that can be utilized to characterize the situation of the smart car or driver or the driving environment. Contexts information is collected when monitoring the roadway, the car and the driver. To implement a context-aware smart car, the context analysis must be considered. Before recognition, the system embedded in smart car must analyze the nature of context. Context data is separated in three layers according to the degree of abstraction and semantics; sensor layer, context atom layer and context situation layer. Figure 1 shows the three layers of context data. Firstly, sensor layer is the source of context data. Secondly, context atom layer servers as an abstraction between the physical world and semantic world. Lastly, context situation layer provides description of complex facts with fusion of context atoms.



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V. PROPOSED SYSTEM FOR SMART CARS

Hierarchical Context Model – Context situation recognition is a reasoning process and should be real time. In order for the system to make good predictions and trigger events, a good classifier for context atoms is necessary. The classifier will analyse the context atoms in two phases; the offline training phase and online recognition phase. Hybrid classifier such as KNN (K-nearest neighbor) classifier or Bayesian and neural network, most currently use, can be implemented to achieve the context recognition.

The offline training phase is used to learn the statistical relationship between context atoms and situations and hence to generate the pattern of every single situation. Also, this can be used as a log of past context atoms. The following illustrates an example how the offline training phase fits in context awareness system A person aged around 65, frequently uses his/her smart car for daily activities. The context-aware system has already captured the driver's behaviours and the latter driving styles, classified them as offline training context data. So, when the same driver enters the smart car next time, through sensors camera, the system will identify the driver, accesses its training context data and adapt according to the user. Hence, the smart car adapts itself to the driver's profile using the offline training context data.

The online recognition phase is used to recognize the current situation according to its pattern in the running time of a smart car.

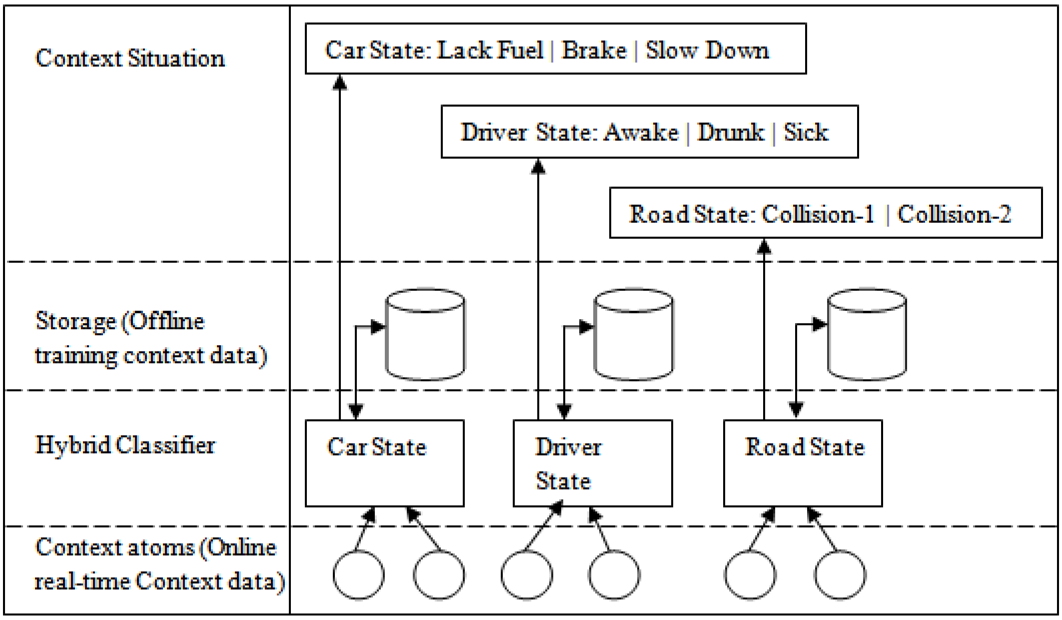

Figure 2: Context situation recognition architecture

Figure 2, defined eight trigger situations in the scenario, including three driver situations, three car situations and two road situations. Collisions-1, and -2 are risk assessments and mean the danger levels. Since assessments apply different features and have different targets, three statistical models have been trained and use the corresponding classifiers to estimate the three kinds of situations. At any given time, the classifiers will recognize the current situation if the situation stays unchanged for a continuous period of time. Only those transitions that last for a period of time will be recognized as the transitions that really happen, while the temporary situations will be ignored and not stored in the training storage.

Context atoms, Ontology definition – Each sensor captures a specific type of context atom. For each type of context atom, a meaningful name must be assigned for application to use the contexts. Ontology is used to define the name to guarantee the semantic understanding and sharing in smart cars. Three ontologies are used are shown in Figure 3. (a) Ontology for car contexts include power system (engine status, accelerograph, fuel, etc), the security system (safety of the car and driver such as airbag, safe belt, anti-lock braking system, navigation system, etc) and conform system (entertainment devices, windows, air conditioner, etc). (b) Ontology for driver contexts refer about the driver's physiological conditions like heart beat, blood pressure, density of carbon dioxide, eyes close or open. The information is used to evaluate the health and mental status of the driver for determining whether he/she is fit for driving. (c) Ontology for road contexts. The environmental contexts are related to physical environments include information about road surface conditions, traffic density, signal lamps, network status, road signs, weather conditions, etc.

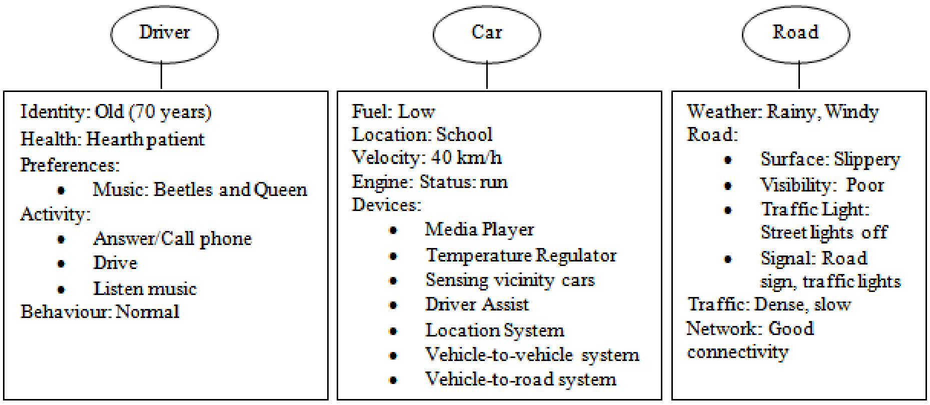

Figure 3: Three ontologies for context atoms

Scenario 1, Smart Car Adapting to Driver's Profile - John Smith needs to drive his two grandsons at school every morning located 10kms from home. Being a heart patient, he usually drives 40-50 km/h. His daily routine activities in his smart car are as follows; (a) Starts engine car at 7h30. (b) Listens 'Beetles and Queen' playlist songs. (c) Drives 10kms, drop kids at school. (d) Drives back home. On a particular day, John Smith seats on his car at 7h50. The weather condition is bad, raining heavily, and windy. Road slippery and due to bad weather condition, traffic flows on road is slow.

When John Smith enters the smart car, the camera sensor immediately captures the person by image processing techniques. The smart car identifies the user as the old driver and through heart beat detector; it captures health information from the driver. The smart car accesses its storage to check the calendar schedules, times and days, and driver's identity who is purposed to be using the car. The smart car matches the collected data from sensors to the context information in the offline training context data sets. Now, the smart car has full knowledge about its driver and adapts itself according to the driver's need; adjust seat, starting playlist song 'Beetles and Queen', monitors the driving speed, predicts the destination in advance and time required.

The smart car is embedded with comprehensive system that detect normal and abnormal driving behaviour using a context-aware system to collect and analyze contextual information about the driver, the vehicle's state and environmental changes and to perform reasoning about certain and uncertain context. The smart car notices a lateness of 20mins. It contacts the nearby base stations via wireless technology provided by VANETs, establishes a shortcut path to reach on time.

Thanks to road sensors, monitoring traffic density and flow, road conditions and weather conditions, the smart car is aware of the currents situation and triggers required actions. Due to bad weather conditions, the driver needs assistance for driving in comfort and safely. So, street lights turn on as car approaches, voice alerts on dashboard to notify the driver on the road sign and traffic signals due to poor visibility. Also, the smart car continuously monitors other vehicles in vicinity and pedestrians through Vehicle Ad-Hoc Network to avoid collisions.

However, halfway the meter gauge fuel indicates low and if changing direction to gas station will result in lateness. The smart car serves the driver to assist him in several ways, the smart car is adapting in every situation the driver is facing. The smart car talks to the vicinity cars to check their destinations and finds another car with same destination. It sends the request to that car, that latter replies on its user's acknowledgement. The children get in the other car and grandpa, John Smith, now can go to gas station and the kids can reach school on time.

Connectivity and information sharing for intelligent mobility – Adopting hybrid schemes for combining vehicle-to-vehicle communication (VVC) and vehicle-to-infrastructure communication (VIC) into a single protocol can become advantageous and allow fast migration from VVC to VIC connectivity depending on the operation context (high/low density, high/low velocity). This paper proposes the use of seamless connectivity in heterogeneous wireless network environments, and in particular adopts them in VANETs, where VVC and VIC represent the main communication protocols. To reach the goal of seamless connectivity, two major problems have to be solved. Firstly, the context-aware system has to be developed on a basis that provides real-time data of the road environments, driver's behaviours and the car itself and from fusion sensors. Secondly, the driver should have easy access to services offered in the network.

The idea for seamless connectivity in VANET is a Vertical Handover technique based on vehicle velocity, where a vehicle switches from a Serving Network (SN) to a Candidate Network (CN) if its speed is below a fixed threshold level.

Seamless connectivity provides the ability for a vehicle to remain connected as it roams around different types of networks. Vertical Handover allows vehicles to stay connected as they connect from one network to a different type of network technology. As the vehicles move in a different network, the smart systems in the vehicles must do auto-configuration in order to change networks without the drivers' intervention. The smart car to achieve seamless wireless connectivity, desires continuous sessions of wireless connectivity. This is achievable by making the smart cars compatibles with heterogeneous existing network technologies. Bus, private cars and heavy vehicles should work in Wi-Fi, VANETs, Wi-MAX, and Bluetooth. The smart vehicles should have multiple interfaces to support multiple technologies.

On the other hand, the problem of a seamless connectivity becomes more challenging in VANETs, because vehicle move across overlapping heterogeneous wireless environments. The complexity grows as there are no restrictions in ubiquitous networks as there in present infrastructure networks. Also, cars with high speed become more difficult to maintain good connectivity across overlapping network technologies. Hence, the solution; VANETs handovers should be performed on basis of specific criteria such as vehicle mobility pattern with considerable velocity and locality information.

Smart Car Prototype – To build a smart car prototype, the hardware infrastructure and software platform are required. A software platform is developed to manage devices, support vehicle-to-vehicle communication and vehicle-to-infrastructure communication and provide runtime environment for the context model and applications.

Hardware Requirements – Intelligent devices, sensors and processors like electronic control units (ECU) need to be embedded in the smart car. Table 1 shows the devices that can be used in the smart car prototype. Various sensors were deployed in the smart car prototype as listed in Table 2.

For road context-sensors; the environment contexts are acquired by a Crossbow sensor board, which provides sensing capabilities including road and weather condition and ultrasound sensors can be used to estimate the distance between two adjacent cars.

The car contexts such as information about velocity, fuel consumption and wheel rotation can be obtained from car CAN bus. Bluetooth GPS receiver determines the car location.

Finally, as for driver contexts, RFIDs (radio frequency identification) can be embedded in smart car to recognize the identity of the driver and passengers. An alcohol sensor, detecting alcohol level of driver, can prevent driver from taking the wheel if above the threshold level.

Cameras were installed to track the movement of eyes and head of the driver. Real-time face detecting and eye tracking can be done by fusion of active sensors. We can still use the eye blink behaviours method and image-based user recognition to compare the detected faces with registered users' face images, by (Pan et al., 2007) and Fisherface algorithm (Belhumeur et al., 1997) respectively. A microphone sensor, to receive the vocal command of driver; "music on", "music off", "weather update", "parking availability" and other commands, were offered to driver.

Table 1: Device list in the smart car prototype

Devices	Types	Purpose
Notebook PC	SONY VAIO FJ	Run the software platform and application.
PDA	400 MHz Intel, XScalPXA255	Conduct the cooperation with software platform in the smart car.
Virtual keyboard **Touch screen**	I-tech virtual laser keyboard FA801-NP/C/T	Provide the passengers and driver with easier interaction.
Wireless router	D-Link DIR-300	Provide users with information services in car.
Camera	Logitech QuickCam Orbit	Capture image of driver's mood and behaviours.
CAN analyser/ Connection	CANalsyt-II CANHub-S5	Necessary analyzing tool for messaging. CAN hub was used to combine several communication nodes in a car.

Table 2: Sensors list in the smart car prototype

	Sensor	Context
Road	Weather Condition sensor Road Condition sensor Ultrasound sensor Microphone Traffic sensor Street lights sensors	Rainy, windy Slippery Distance between 2 cars Loudness Dense Off
Car	Bluetooth GPS receiver Fuel level sensor Accelerometer Hall-effect sensor	Car-location, Fuel consumption Acceleration Wheel rotation, velocity
Driver	Camera Microphone RFID Alcohol sensor	Head, gaze, identity Vocal command Identity Alcohol density

Software platform – A Context-aware platform for the smart car, as shown in Figure 4 is projected consisting of four layers; network layer, broker layer, context layer infrastructure and services layer. (a) Network layer, the smart car should support different network technologies. The smart vehicles can establish a serial-bus system to communicate between vehicles' components (such as engine and the steering system). WLAN 802.11 a/b/g networks support communication between vehicle-to-vehicle and vehicle-to-infrastructure. (b) Broker layer, as the smart car enters a new environment, the sensor broker is responsible for discovery and registration of new sensors added into the smart car. Sensors can transmit data via wireless network WLAN, serial port, Ethernet and USB. The role of the broker is to assign a globally unique address or identity to a sensor, specify the updating frequency and define the fashion for sensor to transmit data and for system to parse data. (c) Context infrastructure has been implemented on the basis of a context toolkit (Daniel et al., 1999) and consists of three parts. Firstly, the context wrapper transforms sensor data into semantic context atoms. Secondly, the context reasoned trains and recognizes context situations. Thirdly, context storage is a repository for historical contexts and provides the advances query services. (d) Service layer, smart cars goal is to create a safer, more efficient and more convenient driving environment for drivers, so specific services should be developed. Most services such as slow down when the distance the front adjacent car is less than safety limits, sending signals for street lights to turn on and off. Also, online services allows driver to get notification from social websites, check messages which are all output to user in voice messages. Intelligent dashboard can display road conditions and assist the driver in location guidance. The ECU role is t parse the message and sends control signals to a relay, which will control the actuator to change its state. Moreover, other intelligent services that can be implemented in the smart car such as self-driving lessons. Smart car with the software platform should be in full capacity to give self-driving lessons to new learners. Roads indications, important information can be displayed via dashboard and by voice alerts. To motivate the building of our smart car prototype, an example is shown in Figure 5.

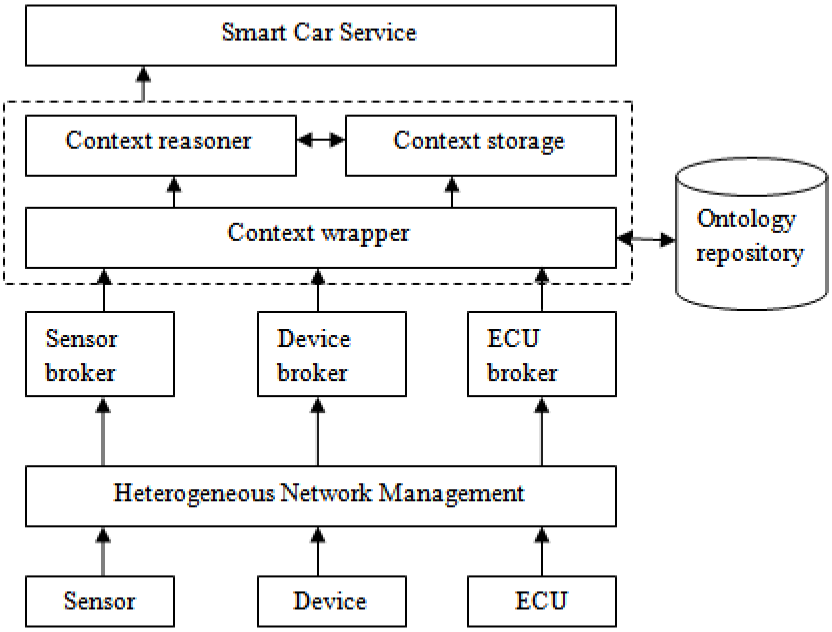

Figure 4: Software platform for smart vehicles

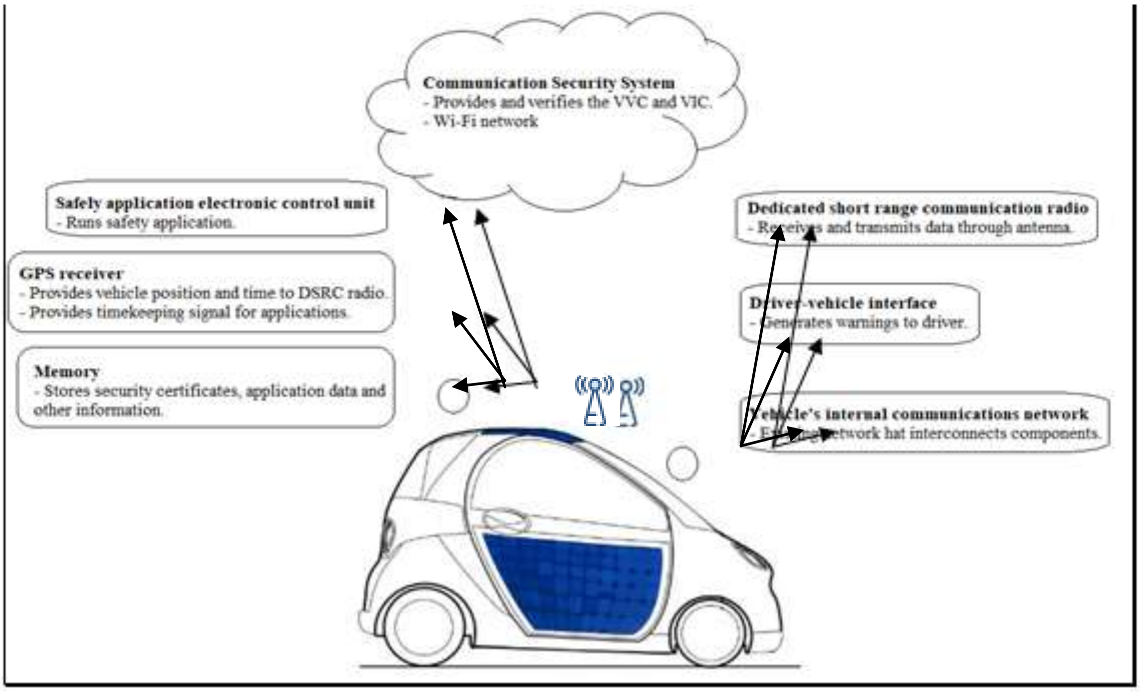

Figure 5: Smart car prototype with built-in sensors and software interface.

VI. EVALUATION PERFORMANCE

In order to assess the performance of the context-aware model and real-time implementation, the architecture of the smart car is evaluated. The evaluation is done on the risk assessment by considering the driver monitoring system. A smart car can monitor the driving environment, assess the possible risks and trigger appropriate actions to avoid or to minimize the risk. The smart car architecture in Table 3 shows the risks assessments.

Traffic monitoring system, various sensors can be used to identify the distance between the car and the other road users. Active environment sensing in-and-out-car will be a general capability in the near future (Tang et al., 2006). The radar sensor gives feedback about the position and velocity of the vicinity car. Multiple cameras embedded in the road environments and cars eliminate blind spots, recognize obstacles and record the surroundings. Also, via wireless technologies such as VANETs, the smart car can get information from the internet or nearby cars.

Driver monitoring system, almost 95% of the accidents are due to human factors and in most cases human behaviour is solely to blame. Smart cars present promising potentials to assist drivers in improving their situational awareness and reducing errors. Physiological sensors can detect whether the driver is fit for driving. With in-built cameras monitoring, the driver's mood and activity is known to the smart car and just the latter adjust itself to the needs and activities of the driver.

Car monitoring system, context data like the dynamic of a car from engine, the brake system can be read and transferred by controller area networks (CAN) to analyze where functionality of car.

Risk assessment verifies the risk of the driving task according to the situation of the traffic, driver and car. Different levels of risks will lead to different responses, including notifying the driver through Human Machine Interface (HMI), intelligent dashboard and triggering actions by car actuators.

HMI is a simple output in terms of voice alerts or dashboard's display that warns the driver of the potential risks. For example, driver's behaviors are sleepy and cameras monitoring driver's eyes identifies eyes closed. So, the tired driver is awakened by an acoustic alarm or seat vibrating.

Actuators, have the tasks to run specified control on the car without the driver's commands. The smart car will adopt active measures in extreme cases where the reaction time of the driver has exceeded the safety threshold. The active measures include stopping the car in case driver enable to react on time, or popping up airbags if the system senses the driver is in danger of collision.

Table 3: Smart car risk assessment

	Risk Assessment
HMI Driver Warning	Seat vibrator, Hash noise, simple message
Car Actuator	Passive protection, slow down, stop car, turn right/left.
Driver Monitoring	Head camera, face camera, body optical camera, alcohol sensor
Car Monitoring	Steering angle sensor, speed sensor, brake pressure sensor
Traffic Monitoring	GPS, laser sensor, forward/side/rear camera

VII. EXPERIMENTATION - EVALUATION OF ACCURACY OF CONTEXT SITUATION RECOGNITION

This experiment was carried out with 13 trigger situation of the smart car, including five driver situations (Awake, abstracted, drunk, sick, drowsy), five car situations (Lack fuel, turn right, turn left, accelerate, slow down) and three road situation (collision-1, collision-2, collision-3), means the levels of danger of collision. As a matter of fact, the driver situation is the most complex one since it deals with face recognition imaging processing. Hence, the driver recognition is taken as worst-case evaluation. From the Figure 6, we can clearly see the increasing trend of accuracy as features (context information) grows. Eventually appropriate contexts information will reduce the error probability. Another way to reduce the error rate is to introduce new and independent context information (features) providing additional information. Even though increasing the number of features will increase the computational cost of both the feature extraction and classification, it is often reasonable to believe that performance will improve.

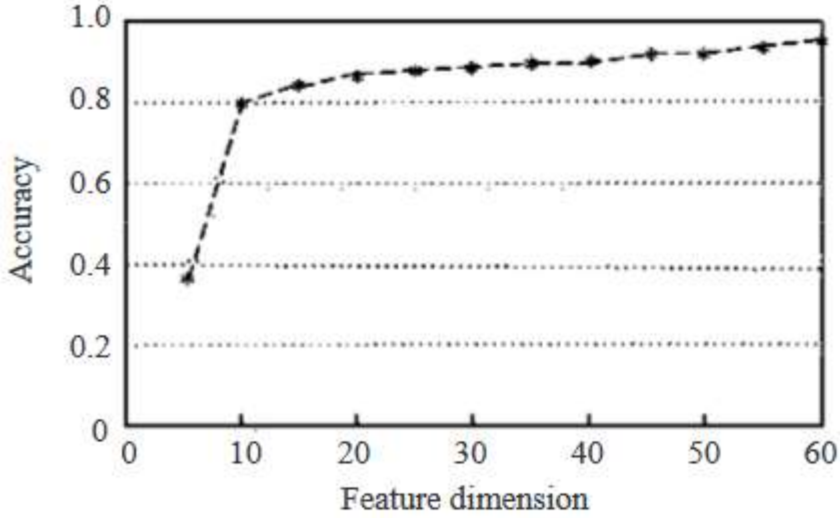

Figure 6: Average accuracy of context situation recognition

VIII. CONCLUSION

Smart cars are a promising domain of ubiquitous computing, and have been subjected to comprehensive researches and greater attention. This paper attempts to build a smart car from the view of context-awareness. Our contributions are threefold: (a) modeling of context-aware the architecture of smart car. (b) A three-layered context model is proposed to represent a complex driving environment. (c) The implementation of a smart car prototype including its hardware requirements and software platform, to service the context awareness system.

Our future work includes application of heuristic approaches on the classifiers and more innovative sensing technologies to detect physiological behaviors of the driver. More focus on the driver prediction behavior will be made.

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