Aware-D: Voice Recognition-based Driving Awareness Detection

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***Abstract*—Driving needs the driver to be in a proper condition, aware enough of the road to ensure safety. Driving under the influence of alcohol has been one of the worst cause of traffic accidents worldwide. In this paper, we propose a novel system to detect the awareness of car drivers when driving, which is related to driving under alcohol (drunk driving). The system will be installed in Android smartphones and evaluate driver's awareness by questioning the drivers with Android's text-to-speech and evaluating the answers with voice recognition before and during driving. The system calculates the percentage of correctly answered and wrongly answered questions. Once the system detects abnormal awareness of the driver, the system will alert the driver and notify a chosen contact with SMS containing the location of the driver.**

Keywords—mobile application, awareness detection, driving behavior, Android system

I. INTRODUCTION

In this fast paced world, mobility of people is very important and transportation is a very essential element to support the mobility of people. One of the most used transportation in the world are cars. Cars, or private cars are used by people to travel quickly from a place to another through the roads, which not seldom take a long time in roads and traffic. There are an estimated number of 1.2 Billion cars active in the roads worldwide, and will grow to 2 billion in 2035, showing the importance and demand increase of cars.

Driving a car needs the driver to be in a proper condition and aware of the road to ensure safety. In many countries, driving a car is restricted to rules limiting the activities done in the car while driving, and the condition of the driver. Drivers in a not proper condition (drunk, sleepy, on drugs, etc.) can cause harm to the other traffic user, in form of a potential to incite accidents on the roads. According to the National Highway Traffic Safety Administration (NHTSA) 33,561 people died in traffic crashes in 2012 in the United States (latest figures available), including an estimated 10,322 people who died in drunk driving crashes, accounting for 31% of all traffic deaths that year.

Our project, Aware-D, a Voice Recognition-based Driving Awareness Detection Android System which tries an approach of human-computer interaction, is made to help the driver and the families (or relatives) of the driver to ensure the driver's condition while driving. With this app, the driver will be provided questions in form of voice, and the driver must answer the questions with voice too. The app will then compare the answers of the driver with the pre-allocated answers in the database of the app to determine if the driver is alert or not. The app can then notify the selected person the condition of the driver. With Aware-D, we hope that we can help reduce the accidents rate because of loss of awareness problem (from tiredness, alcohol, drugs, etc.), and we hope to contribute to this field of study.

To make the reading of this paper easier for the readers, we will consider that our main user is a man, which allows us not to need to precise "him or her".

II. RELATED WORKS

The security problem of human driving behavior is a daily issue that concerns everyone, as far as they use roads as car driver, rider, pedestrian, etc. This must be a reason why there are so many papers about how to help drivers to have a better driving behavior, and so many mobile phone applications developed for this purpose, such as applications to detect Stops, despite their small size, the lack of lighting or the fact that they can become visually obscured from the road[8].

Chin-Teng Lin, Fellow, Chun-Hsiang Chuang, Chih-Sheng Huang, Shu-Fang Tsai, Shao-Wei Lu, Yen-Hsuan Chen, and Li-Wei Ko, in their paper titled "Wireless and Wearable EEG System for Evaluating Driver Vigilance"[1] present a certain vision of that issue, by observing and analyzing the electroencephalographic signals of the driver. Their study aim to develop a driver vigilance prediction system with a wireless and wearable EEG (electroencephalographic) device. They wanted to conceive an efficient prediction model, and implement a real-time mobile app to detect sleepy driving

behavior. They used an EEG sensor system to establish a link between the fluctuation of driving performance and the changes in brain activity. The device used, called Mindo, is a wireless and wearable EEG device to record EEG signals from hairy regions of the driver. That system can process EEG recordings and translate them into the vigilance level. After studies involving 15 participants assigned to a 90 min sustained-attention driving task in an immersive virtual driving environment, the power spectral analysis results confirmed that the EEG activities correlate well with the variations in vigilance. They managed to demonstrate the feasibility of predicting the driver's vigilance in real time. Other studies has been done about how to detect and classify aggressive driving behavior, based on the use of physiological signals or biometric information like electrocardiogram, electro dermal activity, and respiration, in order to propose a driving performance inference system based on the signature of acceleration in the two dimensions and speed.[4] The real time dimension of theses researches is one thing we wanted to work on, because it can help the drivers to improve their driving behavior at the right time, when they are about to drive or even while they are driving. However, the EEG device is not enough accessible to allow any driver to use that system. This is the main objective of our Voice Recognition-based Driving Awareness Detection system: helping the drivers to improve their driving behavior, with an easy and accessible system.

Nadeem Akhtar, Kush Pandey, and Saurabh Gupta, in their paper titled "Mobile Application For Safe Driving"[2], chose to use the smartphone embedded equipment to make an mobile application to help the drivers to improve their driving behavior. They used the smart-phone itself to detect and analyze the driving behavior. Most of the recent smart-phone contain embedded equipment such as accelerometer and GPS sensor. They used data from these sensors to detect the trajectory of the driver, acceleration and deceleration of the car and the road anomalies like bumps and potholes. Their system can take account of various conditions and situations that can cause an accident such as reckless driving causing sudden acceleration and deceleration, sudden lane change, bad conditions of roads, etc. The data are then analyzed and processed through several steps, and an alert is generated if the driver bypasses the safety limits. In that case, the driver's relatives are informed by an automatic call or SMS. Their project present the advantage to be accessible to anyone who has a smartphone, without any need to buy an additional device. Their managed to use the smartphone equipment to analyze the driving behavior of the users, in order to alert them and their relatives if needed. That alert system to the user and other chosen people seemed interesting to us. We decided to develop it in our own system, with some improvements, such as the driver's position, to help the relative to know where the user is and how to contact him or her.

Jiangpeng Dai, Jin Teng, Xiaole Bai, Zhaohui Shen and Dong Xuan, in their paper titled "Mobile Phone Based Drunk Driving Detection"[3], concentrated their work on the drunk driving behavior. Indeed, driving under the influence of alcohol is one of the most important causes of traffic accidents throughout the world. They proposed a highly efficient system to detect such a drunk driving behavior by analyzing dangerous vehicle maneuvers typically related to drunk driving and alert the driver or the police. Their system also uses accelerometer and orientation sensor from smartphones. They conceived a program that computes accelerations based on sensor readings, and compares them with typical drunk driving patterns extracted from real driving tests. If any drunk driving behavior is detected, the application makes an alert to warm the driver or call the police in order to avoid any accident. They studied different kinds of driving behaviors and tested their system with these behaviors. The results showed that their system achieves high accuracy and energy efficiency. In their paper, they report that they planned to add some improvements such as GPS data in the future. Their system also present the advantage of needing a smartphone without any other external device. They tackled the problem from driving behavior analysis, by using sensors and their model depends largely on the driving behavior patterns used. Many other papers propose systems based on smartphones sensors to analyze drivers' behavior[5], mobile phone applications for safe driving incorporating GPS and Bluetooth functions[7]. Drunk driving is a preoccupying issue and many other papers propose systems to detect drunk driving behavior, by using smartphones sensors and evaluate how aggressive the driving behavior is[11].

Some papers also propose to use robotics to complete or replace human driving (then the challenge is to conceive decision making algorithms for the outdoor navigation of mobile robots[6]), or systems to allow communication between vehicles in close proximity with each other or with the roadside equipment[9], and other driving assistance applications using VANET systems[10].

Those papers introduced above present different ways to tackle the issue of loss of attention in the driving behaviour. Some papers offered a solution by analyze the electroencephalographic signals from brain activity, some others use smartphones equipment to analyze concrete driving trajectory and behaviour.

We wanted to tackle that issue by using a friendly mobile application that could be almost seen as a game more than an unpleasing application. The aim was to conceive a question system to detect loss of awareness. In order to be relevant, that application had to determine if the user is able to drive correctly before they start to drive, and continue to verify the user's awareness while they are driving. Indeed, they are many factors that can make that awareness decrease, such as tiredness or alcohol, and these two factors can evolve in time for example. That is the reason why our system needed to be continuous during the drive. An application is more accessible and user-friendly if the user does not need to buy any other device. We also wanted to contribute to the different existing solutions about dangerous driving behaviour by developing a

system that could alert the users and their relatives (the people the user chose to be alerted), inform them about the driver's current position, but with no automatic call to the police, with seemed to be a kind of denouncement and may not encourage people to use that application. The objective is to help the drivers to improve their driving behaviour in order to contribute to safer roads for everyone and not to afraid people with repression.

III. System Design and Implementation

In this section, we will present the overview of our design, the high level view of the algorithm design, and the implementation of our system.

A. System Overview

Figure 3.1: System Overview

Our voice recognition-based driving awareness detection system does not need any external device. The user only needs a smartphone, whose specifications are explained below. The overall operation is pretty simple: very simple vocal questions are asked to the driver, before the drive to check his level of awareness, and during the drive, at a certain frequency, to help him to stay aware and concentrated, and eventually alert him if the app detects a loss of awareness. The cycle of vocal questions during the driving can only be stopped for two reasons: the driver decides to end it (usually before he is arrived) by clicking a button, or the app detects a loss of awareness and prompt the driver to stop driving for a moment (then the questions session ends).

Our awareness detection system consisted of 6 parts: the speaking module, the database module, the GPS module, the SMS module, the statistics, and the main algorithm which determines if the driver seems to be aware enough.

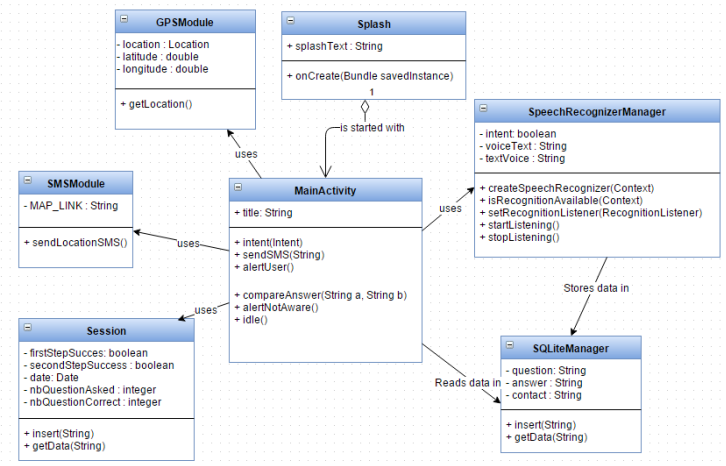

Figure 3.2: UML Class Diagram of Aware-D

The Speech Recognizer Manager listens what the drivers says and converts them into text representation to be processed in the Main Activity. We used Android's recognition service[13] and text-to-speech[12] class to interact with the user, which is implemented in MainActivity.

The main algorithm, in MainActivity, calculates and determines whether the driver is capable to start driving or not, and detects if the user is starting to get unaware while driving.

The SQLite Manager (through two classes, one to monitor the database and one to access it and read the data) manages the preset database file and query them into text representation to be used by the system. The database manager will also store the statistics generated by the system into a database file.

The GPS module get the driver's position from the smartphone'GPS sensor. That position consists of a latitude and a longitude.

This position is used by the SMS module. That module create a String message, containing a Google Maps link with the GPS position. That String is sent by SMS to one or more people chosen by the user. By accessing the settings, the user can add and modify the contact they want to inform in case of loss of awareness detected. If some user's relatives receive such a SMS, it will be easy for them to click on the Google Maps link and see where the user is.

Statistics will allow the user to see his previous data and results for the 10 last uses. Some information, such as the date and hour of these uses and the results (has he managed to success the first part before driving, and has he reached his destination with an "aware" diagnostic), will be displayed on a graph to show the evolution of the user, as shown in part 4.

The percentage of well-answered questions is displayed for each use as a bar chart. The limit of 66% is also displayed on the percentages axis to make more readable the success (or failure) of the driving part. If the app detects a loss of awareness because of too many errors by answering the vocal questions, the system will prompt the user to stop driving for a moment and will end the questions session. Then the bar will

not reach the limit of 66%. It will be easy for the user to see in which use he succeeded or failed thanks to that limit. If the user fails during the first questions, before the drive, no result bar appears.

All these data are store into the smartphone database, as well as the questions, answers, contacts and user's name.

If there is no error, the user clicks on "Start Driving" and install the smartphone within earshot. During the whole drive, questions will be asked every five (5) minutes. The tolerance of mistakes is two wrong response for six questions asked. That means that, for example, if the user makes three errors while answering the six first questions, the app will consider that it suggests a lack of attention that could be detrimental for all the road users. A message will then be displayed, prompting the user to stop driving and take some rest. A SMS will also be sent to the contact added by the user. That SMS will contains a Google Maps link with the position of the driver at this moment.

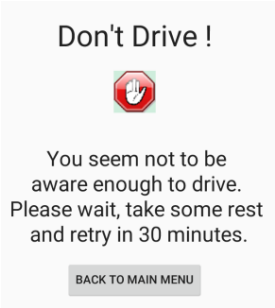

Figure 3.4 : Don't Drive screen

The questions are very simple. The database contains the questions and also the acceptable answers. The user's vocal answer must contains the correct response of the database to validate the question. For example, those questions are asked by Aware-D: "What is the capital of United States of America?", "How many letters in the word 'cat'?" and "Are you drunk?". The acceptable responses are respectively "Washington" or "Washington D.C.", "Three" and "No". If the user answers "Washington is the capital of USA" to the first question for example, the response is correct, because it contains the word "Washington".

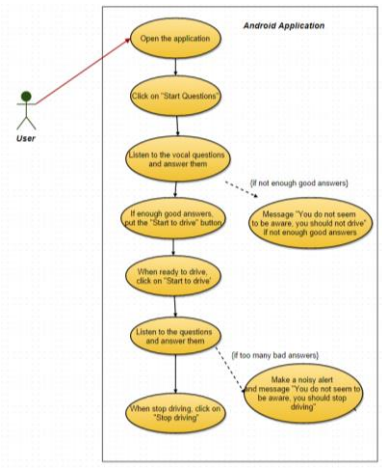

Figure 3.5 : UML Flowchart of Aware-D

B. Questions to detect losses of awareness

Since there is no psychological or behavioral survey about how to measure the awareness of someone by discussing with them or asking them questions, we had to create our own questions.
These questions had to be simple enough to be answered with no need to reflect a lot, because the main objective is obviously to help the driver to stay focused on the road.
Therefore, we invented very instinctive questions, such as easy mental calculation (i.e. *"What is 3x4?"*), logical issues (i.e. *"Are your parents older than you?"*) or basic universal knowledge (i.e. *"What is the capital of USA?"*). Obviously, these questions are not legitimate since they are not based on any survey.

C. Algorithm

This is the pseudo-code of our algorithm to estimate if the user seems to be aware enough to start to drive.

```
NB_QUESTIONS_TO_ASK = 3
dont_drive = false ;
nb_questions_asked = 0 ;
while ((nb_questions_asked < NB_QUESTIONS_TO_ASK) and not
dont_drive)
        askOneQuestion() ;
        nb_questions_asked ++ ;
        if (answer is false)
                dont_drive = true ;
        end if
end loop
if (dont_drive)
        promptMessage("You shouldn't drive);
else
        startDriveActivity() ;
end if
```

Figure 3.6: Pseudo-code of the algorithm which estimates if the user seems to be aware enough to drive by using his answers to the questions asked

This is the pseudo-code of our algorithm to estimate if the driver seems to stay aware or not during the drive.

```
MAX_WRONG_ANSWERS = 2
NB_QUESTIONS_PER_PERIOD = 6
nb_questions_asked = 0
nb_wrong_answers = 0
still_driving = true
too_many_errors = false ;

while (still_driving & not too_many_errors)
        askOneQuestion() ;
                nb_question_asked ++ ;
                if (answer is false)
                        nb_wrong_answers ++ ;
                end if
                if ((nb_wrong_answers modulo
NB_QUESTIONS_PER_PERIOD) >= MAX_WRONG_ANSWER)
                        too_many_errors = false ;
                end if
end loop
if (too_many_errors)
        promptMessage("You should stop driving") ;
else
        closeActivity() ;
end if
```

Figure 3.7: Pseudo-code of the algorithm to estimate if the driver is still aware enough to continue his drive by using his answers to the questions asked

The Boolean still_driving is associated to the button "Stop Driving" on the screen. At any moment, the user can click the button to stop the questions because he is arrived. Then, the application will go back to the main menu and will be ready for another awareness detection.

D. System Implementation

We implement our system on Android Xperia Z1 Compact phone with API level 21 (Lollipop 5.0). The phone provides microphone and GPS needed by the system, and voice recognition with text to speech module used by our system.

The system is developed in Java, with Android Studio v1.3.2 as the IDE and Android SDK 23.0. The system produces 10 classes and 3 xml layouts, which are the main system classes, the applications' configuration class, and the statistics viewer class. The user has to press the driving button to start the system-user interaction. Aware-D will first ask three initial questions which the user has to correctly answer, to get into driving mode. In the driving mode, the calculation algorithm will start monitor the user's awareness level as the user drives and interacts with the application. The app will constantly ask the user with random questions from our database every 5 minutes. If the threshold is exceeded (the algorithm detects unaware driving), the app will give notification to the user and alert previously selected contact by sending SMS containing the user's location.

IV. Analysis

We evaluate our system by testing the main function of the system, the questioning and answering algorithm, and the driving points percentage calculation to determine if the driver is feasible to drive or not. In this section we will describe how we collect the data and analyze the system's results produced in the app's statistics of driving.

A. Collecting the data

We detect unaware driving behavior mainly by evaluating the user's answers within our preset threshold. We collect the data by simulating unaware user behavior, for example sleepy behavior and imitating drunk driving behavior. The data is purely the number of correct and incorrect answer given by the driver. We also test the application by simulating normal/aware user behavior's answers. In the testing, we used a set of 43 questions, which are asked randomly every 9 seconds to shorten the evaluation time. The application will record the user's answers along with the results in every driving session. If the application detects no response, it will ask another question again in 5 seconds, without adding the not responded question to the statistics. The application will detect unaware behavior after the threshold of 2 wrong answers every 6 questions answered. Driving points will be calculated by dividing the number of rightly answered questions with the total of questions asked. If the user doesn't pass the three initial questions, the user will get 0 points.

The application can be run in the background without needing to open the app all over the driving session. Each driving session records the start time, end time, and statistics of the total answers answered, along with the wrong or right results. We use the statistics to show our evaluation regarding to the user's behavior detection.

B. Experimental Results

Figure 4.1 shows the last 5 driving calculated by our system. We created 5 scenarios representing the possible events in the driving.

The first and second scenario in the figure represents the normal driving behavior done by the driver. It is done by correctly answering the three initial questions, and staying under the threshold of 2 wrong answers over 6 questions asked, which have to produce at least 66 points from the start driving point, until the stop driving point. The first and second scenario yield 75 and 87 point respectively, which are in the normal driving behavior area.

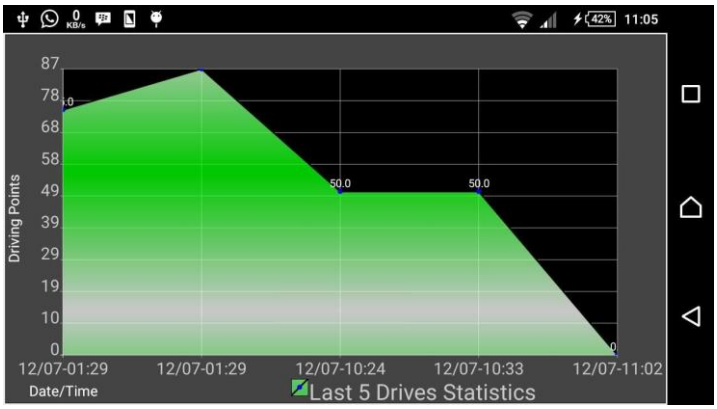

Figure 4.1: Statistics chart as displayed in Aware-D

The third and the fourth scenario represent detected unaware driving. We passed the first three initial questions, and failed the when-driving questions. The scenarios yielded 50 points, which exceeded the threshold. In the failing scenarios, each sends messages to a previously set contact containing the driver's name, and the last detected location.

The last scenario represents the user failing the first initial questions test. The system automatically assigns zero points, and asks the user to repeat this session again. Every failed initial test will be counted as a failed session by the system, without sending any SMS alert.

V. Conclusions

This paper presents a voice recognition-based awareness detection system implemented for Android smartphone, which aims to help drivers to keep their awareness and stay focused on the road while driving. The purpose is to provide vocal questions to test the awareness of the user before the drive and during the drive. The absence of serious survey about means to measure awareness by talking with the person made us create our own questions, what cannot be entirely reliable in

terms of human behavior. However, we hope that our contribution can help drivers to stay more aware while driving than without Aware-D, and we propose the reader to consider our application as a technical base to provide a very reliable voice recognition-based driving awareness detection system, as soon as some surveys will be done about how to measure the awareness of someone by asking them relevant questions.

VI. Further Discussions

In this section, we discuss further development and other potential topic on this issue, in term of approach and system design.

In order to improve our awareness detection, some functionalities could be added. The objective is always to manage to detect the most precisely the loss of awareness during the drive. For this purpose, smartphones' front cameras could be used, to analyze the user's facial expressions, and in particular the eyes which must stay open and reactive.

To be more pertinent concerning the questions, a psychological and behavioral survey should be done about the loss of awareness during the drive and how the brain reflects in that situation. Such a survey would allow psychologists to invent series of relevant questions to estimate the level of awareness of someone during the drive.

What to do when the application detects a loss of awareness could also been discussed. There are different possibilities, different ways to react. Some papers propose to directly call the police[3], some others just alert the driver[1][2]. We decided not to alert the police, which could be a kind of denouncement from a non-infallible system, but do more than just alerting the driver. Sending SMS to the driver's relatives is golden mean. But that functionality could also be improved. Indeed, the user's relatives may not see that SMS soon enough, and even if they do, it can be complicated to help the driver who may be far from the person who has been contacted. How that person should react? They can call the driver, but it could disturb him even more. And how to incite the driver to have a break if he is not aware of his dangerous behavior? Alcohol for example may sometimes give the driver the impression that he is completely aware. This issue concerns all the systems which aim to help drivers to drive carefully. Science and psychology should work together about this question to conceive better means to fight the loss of awareness on the road.

Acknoledgement

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