

# Portable Reckless Driving Detection System

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**Abstract-** We present a portable system that detects bad driving behaviors of a bus using a 2-axis accelerometer. The system can identify four driving events: take off, brake, turn left, and turn right using a rule-based method. Then, the system gives scores to the behaviors detected by fuzzy logic rules. The system verification is done by 11 volunteers who keep track of driving events and scores according to their feeling. The scores from three volunteer are averaged and compared with that from the system. The results indicate an accuracy of 88.04% for taking off events, 87.21% for brake, 88.84% for turning right, and 84.36% for turning left.

## I. INTRODUCTION

Development of modern cities requires a strong foundation of public transportation. Bus system is popular because it is cheap and can cover a large area. However, transportation with buses has low safety because it has uncontrolled factors such as the drivers. Reckless bus drivers are one of the reasons for bus accidents in Bangkok metropolitan. In each accident, there were tremendous loss of lives and properties. It should be prevented at all cost. Therefore, we propose a system that detects bad driving behaviors. These behaviors are harsh forward, sudden brake, and turn quickly. With the requirement that the system has to be carried on to the bus, we selected a sensor that needs no installation. We chose an accelerometer with an aim to measure the jerkiness of driving, and use it as an indicator to the driving behavior.

Researches in detection of bad driving behavior are as follows: Kan Deng proposed learning and detect driving from time series data, using the Auto Regression Moving Average model (ARMA). [3] Nobuyuki Kuge proposed a driver behavior recognition method using Hidden Markov Models (HMMs) to characterize and detect driving maneuvers and placed it in the framework of a cognitive model of human behavior. HMM-based steering behavior models for emergency and normal lane changes as well as for lane keeping were developed using a moving base driving simulator. [5]. Research detection driving behavior at the city environment : Dejan Mitrovic proposed a simple and reliable method for the recognition of driving events using hidden Markov models(HMMs), by studying time series data. A data acquisition system was used to collect longitudinal and lateral acceleration and speed data from a real vehicle in a normal driving environment.[2] Xiaoliang Ma proposed a model of car-following behavior, developed and implemented a consolidated fuzzy clustering algorithm to classify different car-following regimes from the preprocessed data. The algorithm considers time continuity of collected driver-

behavior patterns and the classification of continuous car-following.[8] Research predict driving behavior at the city environment : Dejan Mitrovic proposed the use of place-based positioning and navigation techniques to provide support for navigation tasks which are not adequately supported by conventional car navigation systems and the possibilities of short-term prediction of vehicle movements by various neural network architectures.[1] Nuria Oliver proposed a smart car testbed using a real-time data acquisition system and a machine learning framework for modeling and recognizing driver using the Hidden Markov Model.[6]

In this paper, we present a portable reckless driving detection system. It can verify driving behavior of the bus driver in real driving situations by putting it near the backside of the bus driver's seat. We chose a 2-axis accelerometer to measure the impact of acceleration from the driving behaviors. We used a rule-based method for identifying driving events and used a fuzzy logic to give scores to the behaviors. The fuzzy logic is used for calculating score, because we want the system to emulate human feelings of bad driving behaviors. Fuzzy logic is suitable because we can simply adjust the rules and the range of membership to correspond with the score from our reference volunteers. The block diagram of the overall system is shown in Figure 1.

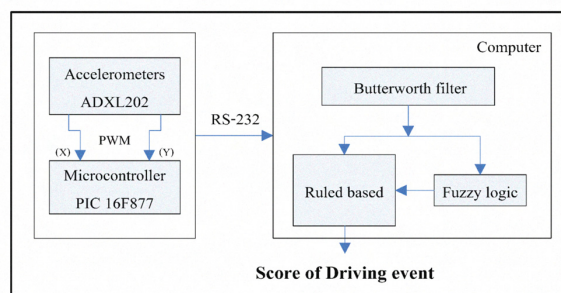


Figure1. Portable Reckless Driving Detection System

The paper is organized as follows. Section 2 presents a method to measure bus's acceleration using a 2-axis accelerometer. Section 3 presents a Ruled based system. Fuzzy inference system is presented in Section 4. Finally, we discuss the results and conclusions in Section 5 and 6.

## II. SYSTEM OVERVIEW

We use a 2-axis accelerometer by putting it at the backside of the bus driver's seat to detect vehicle's activities: i.e. take

off, brake, turn left and turn right. The XY reference axes are shown in Figure 2. An ADXL202 2-axis accelerometer is used for sensing the acceleration of the bus. The acceleration value in the X axis could indicate take off and brake behaviors. The acceleration value in the Y axis could indicate turn left and turn right behaviors.

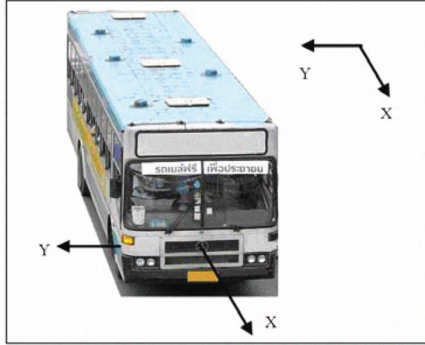


Figure2. Direction of acceleration.

We use a PIC 16F877 microcontroller board as an interface between the accelerometer and a PC. The raw signals of the X and Y axes need to be preprocessed to eliminate offset and noise before passing them to the ruled based and the fuzzy logic by butter-worth filter. We only want to measure the reflection of forces that imposed on the passenger without caring about the direction. Next step, we eliminate the DC offset on all axes by using a high pass butter-worth filter with a frequency cutoff 0.02 Hz at order 1. Finally, all signals are passed through a low pass butter-worth filter with a frequency cutoff 2 Hz at order 3 to get rid of jittering noises. Figure 3 shows an algorithm used for preprocessing the signals from an accelerometer.

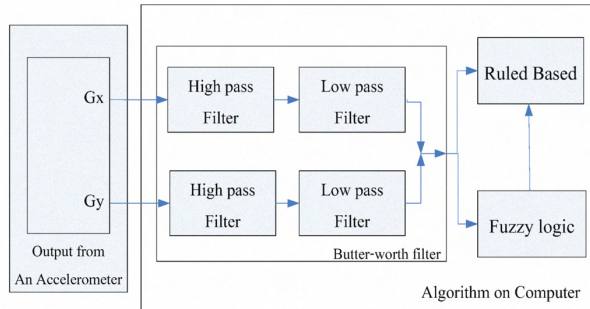


Figure3. Preprocessing steps for accelerometer signals.

### III. DRIVING BEHAVIOR CLASSIFICATION USING RULED BASED

Ruled based system has identified the types of events: take off, brake, turn left, turn right and matching the event to a score form the fuzzy system. Ruled based system has divided into two sections.

#### A. Identification of driving events

The values of acceleration in the X axis could indicate take off and brake behavior. The acceleration in the Y axis could indicate turn left and turn right behaviors. Rules are defined as follows.

If ( Acceleration in the X axis  $> 87.5$  mg. ) and (Connected time  $< 275$  ms. ) is Take off.

If ( Acceleration in the X axis  $< (-87.5$  mg.) ) and (Connected time  $< 320$  ms. ) is Break.

If ( Acceleration in the Y axis  $> 150$  mg. ) and (Connected time  $< 275$  ms. ) is Turn left.

If ( Acceleration in the Y axis  $< (-150$  mg.) ) and (Connected time  $< 275$  ms. ) is Turn right.

We select a threshold for detecting driving events, in which we divide the acceleration into two levels: action and inaction. Inaction values of acceleration in the X axis are below  $\pm 87.5$ mg. and the Y axis are below  $\pm 150$ mg. Connected-time is used to differentiate strong events from light events, in which we consider as trivial. The appropriate values of the thresholds are derived from trial and error.

#### B. Matching event to the score form fuzzy logic.

After the event is detected, the system will search for a maximum score from the fuzzy logic system within this event's period, and uses it to be the score for this driving event.

### IV. BEHAVIOR EVALUATION USING FUZZY LOGIC

The fuzzy rules are used to give scores to driving events. The rules are designed to determine a score from the values of accelerations in both X axis and Y axis. So the membership function and fuzzy rules of the fuzzy system has to be a joint relationship by the data from both X and Y axes. We manually adjust the scope of memberships by trial and error until it fits the human score from the questionnaires. Figure 4, 5 and 6 show the membership function of the fuzzy system. We used Mamdani mean inference and the centroid defuzzification method. The fuzzy rules are shown below.

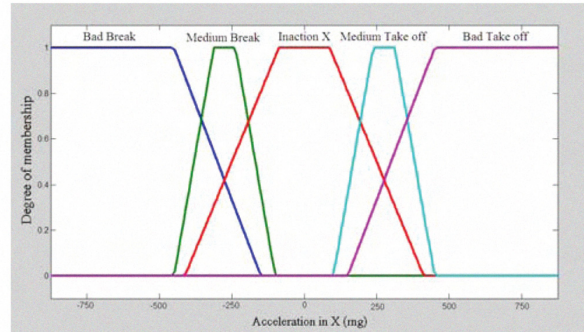


Figure4. Input1 are member ship function X axis.

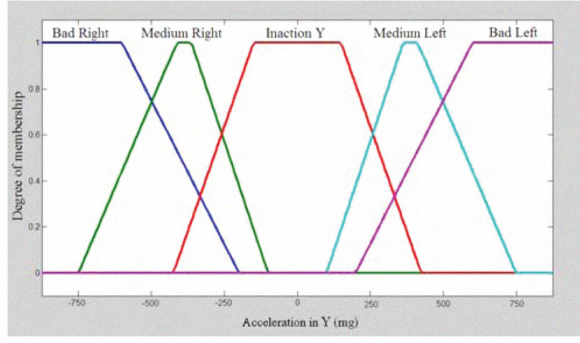


Figure5. Input 2 are member ship function Y axis.

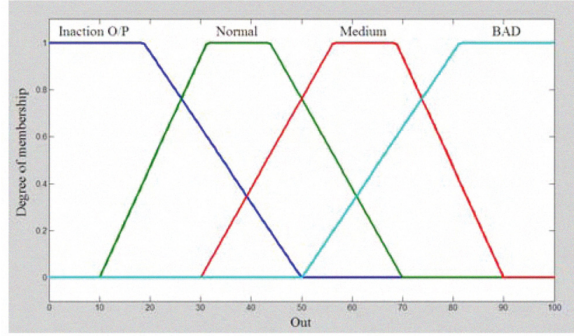


Figure6. Member ship function of output.

#### Fuzzy rules

##### Inaction

IF input1 is Inaction X AND input2 is Inaction Y,  
THEN output1 is Inaction O/P

##### Medium Break

IF input1 is Medium Break OR input2 is Inaction Y,  
THEN output1 is Medium

##### Medium Take off

IF input1 is Medium Take off OR input2 is Inaction Y,  
THEN output1 is Medium

##### Bad Break

IF input1 is Bad Break OR input2 is Inaction Y,  
THEN output1 is Bad

##### Bad Take off

IF input1 is Bad Take off OR input2 is Inaction Y,  
THEN output1 is Bad

##### Medium Right

IF input1 is Inaction X OR input2 is Medium Right,  
THEN output1 is Medium

##### Medium Left

IF input1 is Inaction X OR input2 is Medium Left X,  
THEN output1 is Medium

##### Bad Right

IF input1 is Inaction X OR input2 is Bad Right,  
THEN output1 is Bad

##### Bad Left

IF input1 is Inaction X OR input2 is Bad Left, THEN  
output1 is Bad

## V. RESULTS

We used eleven volunteers as references in our tests. The bus in our experiment starts from Pracha-utid Road to Hua Lamphong Railway station. The route is within Bangkok Metropolitan, which is a city environment. Testing period starts at 21:20 to 22:10. The volunteers are asked to record time and give score at all happening events. The score is ranged from 1 to 10, where 1 is very mild and 10 is very bad and dangerous driving. Table I shows an example of the Questionnaires. Figure 7, 8, 9 and 10 show events score from volunteers. After that, we normalize the score of the answers from questionnaires with the standard normal distribution, as in (1)

$$z = \frac{x - \mu}{\sigma} \quad (1)$$

TABLE I  
EXAMPLE OF THE QUESTINNAIRES.

| Time  | Take off | Brake | Turn right | Turn left | Score |
|-------|----------|-------|------------|-----------|-------|
| 21:00 | X        |       |            |           | 2     |
| 21:00 |          | X     |            |           | 3     |
| 21:01 |          |       | X          |           | 4     |
| 21:02 |          | X     |            |           | 4     |
| 21:03 |          |       |            | X         | 6     |

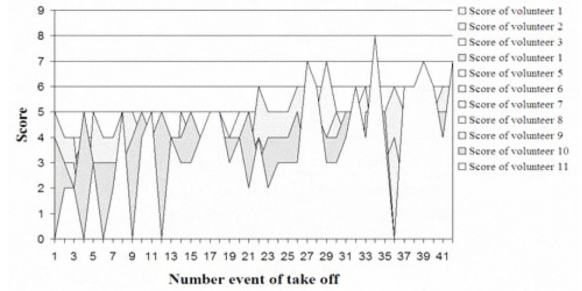


Figure7. Score of all take off from volunteers.

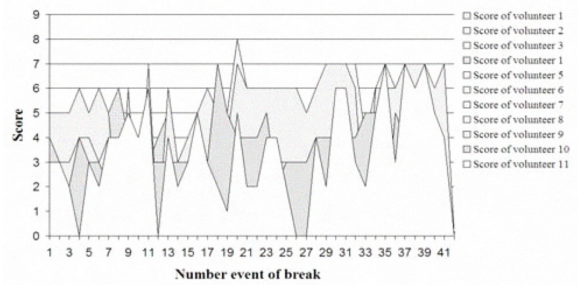


Figure8. Score of all break from volunteers.

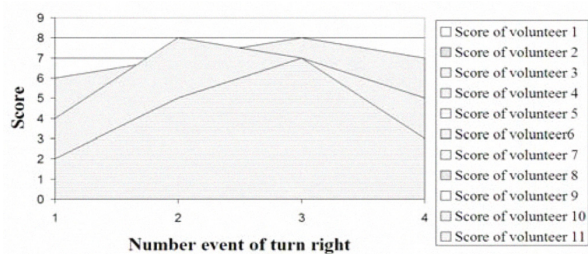


Figure9. Score of all turn right from volunteers.

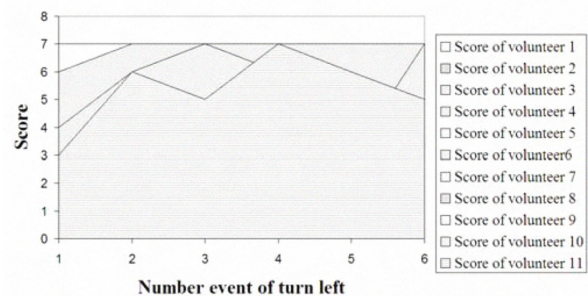


Figure10. Score of all turn left from volunteers.

We calculated an average of the normalized score and compared it with the output score from the system. Figure 11, 12, 13 and 14 show the result of this test.

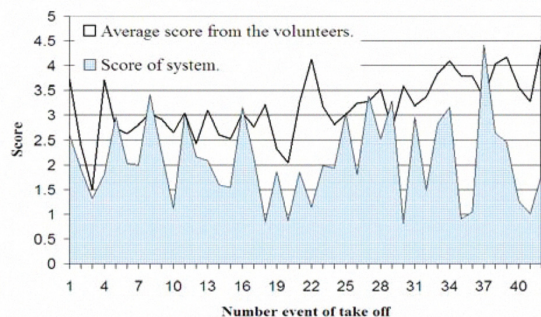


Figure11. Result of take off.

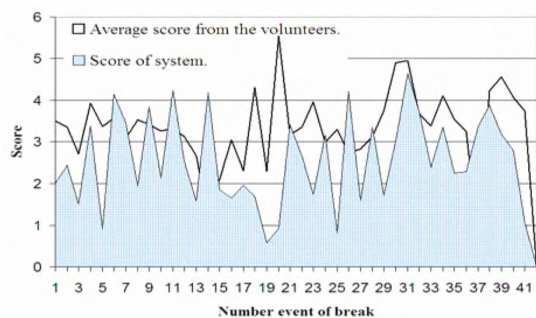


Figure12. Result of break.

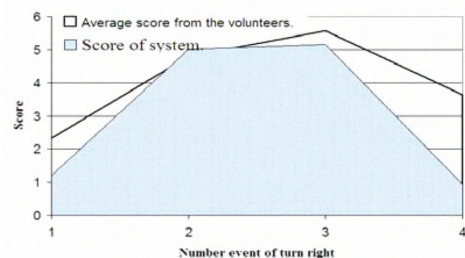


Figure13. Result of turn right.

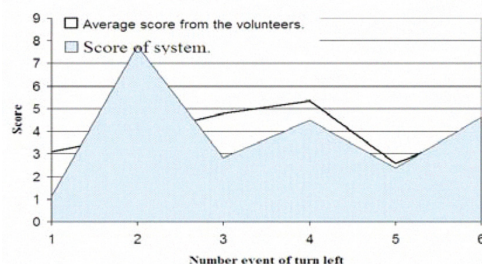


Figure14. Result of take left.

Figure 11, 12, 13 and 14 show the output compared between the fuzzy system and the average score from questionnaires. The percentage of error are 11.96% for take off, 12.79% for brake events, 11.16% for turning right, and 15.64% for turning left. Although, this system give score had errors, because the percentage of true value according to feeling of difference human.

## VI. CONCLUSIONS

In this paper, we proposed a portable system that uses an accelerometer to detect bad driving behaviors. The data are passed to the fuzzy system and the rule-based system. The test results show that our system performs well with an accuracy more than 80% compared with human opinions.

## VII. REFERENCES

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