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Exploration and Showcase ofFSMs and HFSMs Traffic inLow-Cost Educational Driving Simulator

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The organisation of this article is as follows. Section 2 explains the basis of implementation of NPCs. Section 3 explains our methodology between FSMs and HFSMs. Section 4 would be our discussion on the technologies and potential effects of the implementation. Section 5 conclude the article.

2 Basis of Implementation

As we are developing an educational driving simulator, one of our objectives are to help learner drivers to gain more hands-on experience and engrain certain muscle memory and reflexes for real world driving. Hence the format of standardised driving tests will not suffice and clicking to identify hazards with photos [9] is not engaging. With this reason, we implemented some NPCs into our driving simulator to mimic Malaysian traffic conditions to challenge our learner drivers. As this challenges can help to create a great learning experience with interactive instructions and stimulation [4, 7, 10]. Since there is a link with positive results on specific skill-oriented aspects of driving and simulation [1, 17], there is no reason to shrug off an implementation of such NPCs. The "World's Fastest Gamer", James Baldwin, has also proven that racing and driving skills are transferable from virtual to reality by winning his British GT debut after winning the E-sport racing championship "World's Fastest Gamer" 2019 [8]. With multiple studies and a real life example, it is hard not to implement some NPCs to challenge learner drivers to develop necessary driving skills.

3 Methodology

3.1 Educational Driving Simulator

Our educational driving simulator is built on Unity Engine, the engine came with some basic programming that requires setup and some further codes to create a functioning NPC. The purpose of building these NPCs in the driving sim is to act as traffic, these NPCs will be taking the form of cars, roaming around the streets or creating situations based on certain conditions. Such NPCs is able to mimic Malaysian traffic and provide our users with challenges to react to, we then can implement tests based on these NPCs (Fig. 1).

3.2 Finite State Machine

We used a simple finite state machine in the NPC cars to allow them to follow a set route. The NPCs were programmed to go to a set checkpoint, after it reaches a

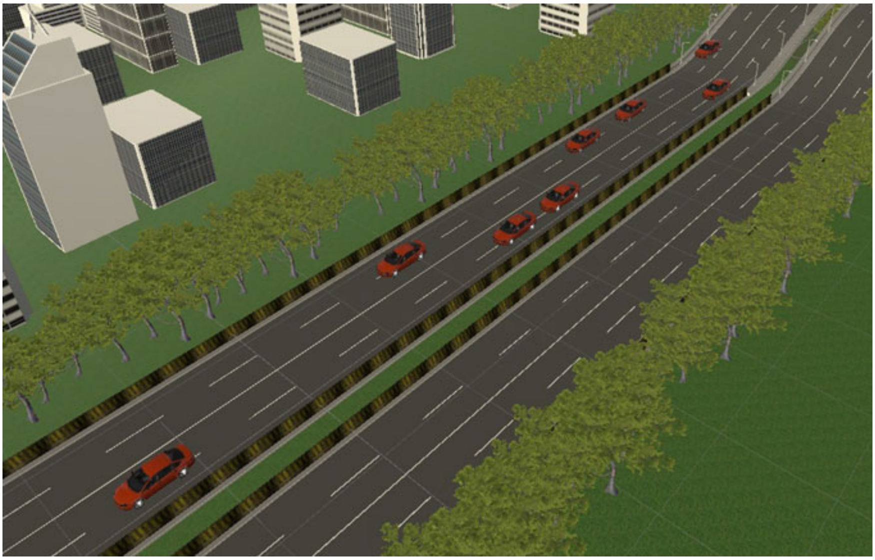

Fig. 1 A few NPC cars as traffic

checkpoint, it will look for the next checkpoint and starts its journey to it, this is done repeatedly without halt. In this sense, whenever the conditions of reaching its latest check point is fulfilled, it will check and reset its look ahead to the next latest check point, then repeats this simple cycle (Figs. 2 and 3).

With this simple state FSM, we were able to create a realistic static roaming traffic.

3.3 Hierarchical Finite State Machine

To create a continuous flow of traffic without halt, we designed a simple HFSM using our simple FSM as base. The HFSM simply checks if the NPC has reached its final point and resets its position back to an initial point. This simple HFSM creates a sense of uninterrupted continuous flow of traffic for the user (Figs. 4, 5, 6 and 7).

We also designed a simple NPC car which would cut into the users' lane and would cut back to its lane after the user fulfilled a certain condition. The condition is still in progress as we are still deciding what would be the best condition to trigger the action. The purpose of having this NPC is to create challenges for the user (Figs. 8, 9 and 10).

With the use of such HFSMs, we were able to create and mimic real traffic to a certain extent based on users' input, position and condition.

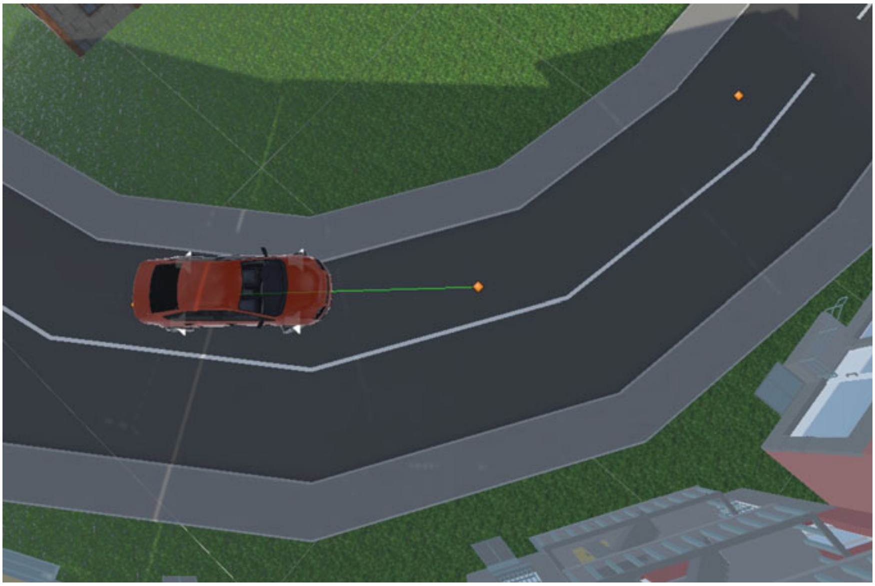

Fig. 2 An NPC car following the next checkpoint

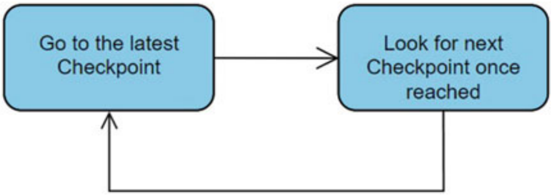

Fig. 3 State diagram of the basic NPC's

4 Discussion

4.1 Technology

With our project using FSMs and HFSMs in the traffic NPCs, we did imagine our project to use more advanced techniques like Artificial Intelligence and Machine Learning. There is a desire to create such NPCs that function like actual cars in the real world based on autonomous driving (AD) technology. This development path, however, is extremely complex. Although, this is not impossible as shown by BMW. BMW Autonomous Driving department has built and tested their AD technology in unity [5, 6], they used such technology to run more than 240 million virtual kilometers. Their virtual AD cars can drive themselves in any various traffic situations with a variety of weather conditions such as night driving.

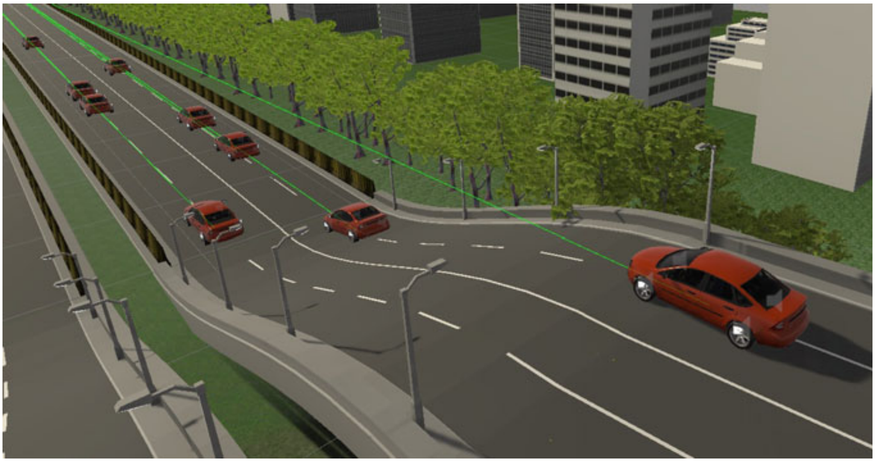

Fig. 4 Traffic NPCs from initial point

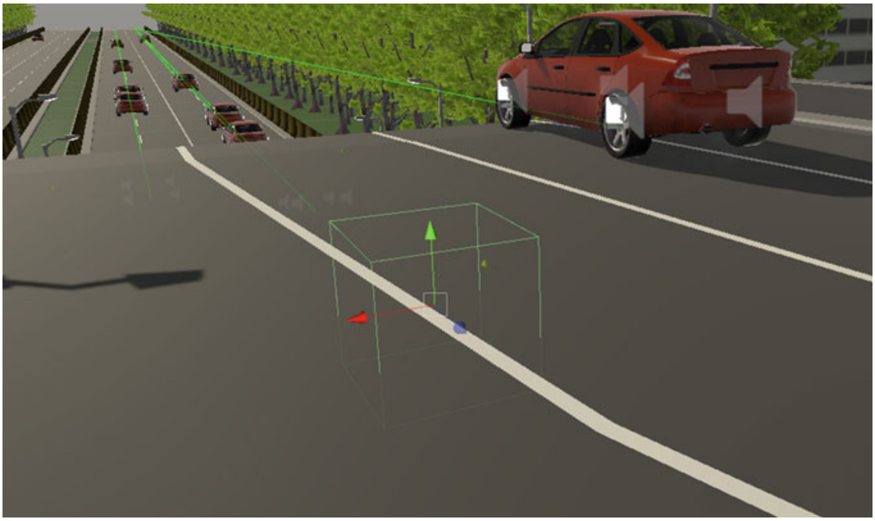

Fig. 5 The initial point of the NPCs

The prospect of bringing such technology into low-cost educational driving sims is appealing. With independent NPC cars that roam around and will react to the users' action without pre-programmed conditions or reactions will provide a sense of real-world randomness to the user as we have difficulty predicting what these AD NPC's actions.

The advantages of AD driving tech in driving sims are noticeable compared to FSMs and HFSMs but it has its own disadvantages that make FSMs and HFSMs more approachable. We tabulated a simple table below to discuss their comparison (Fig. 11).

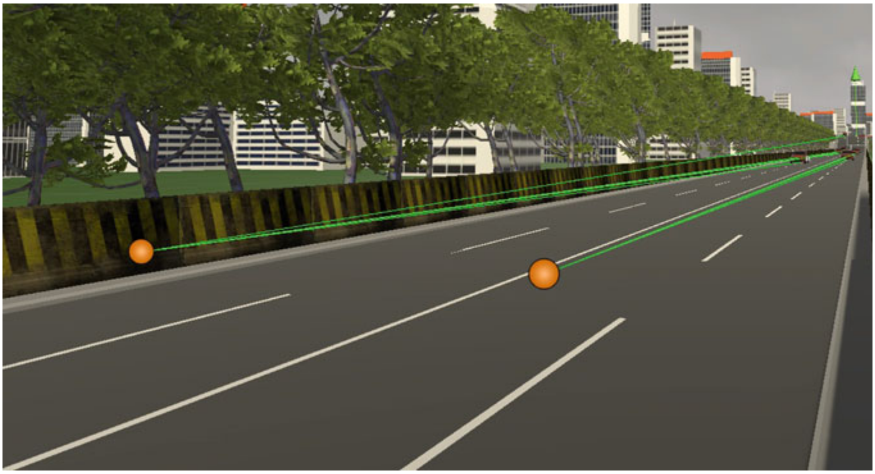

Fig. 6 The end point for NPCs

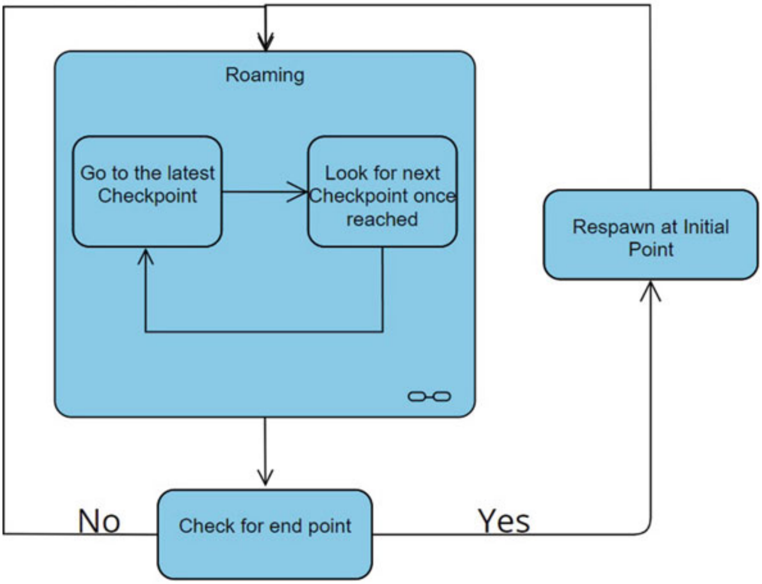

Fig. 7 State diagram of traffic NPCs

Shown in the comparison chart, it is realistic that we chose FSMs and HFSMs for our project as we can design and tailor these systems for our NPC to suit every situation that we design. Although AD can react and adapt on the fly, their behaviour is unpredictable. Developing HFSMs are also more approachable compared to designing AD as they are immensely complex and require a lot of manpower.

Fig. 8 The path of NPC

Fig. 9 NPC cutting in lane from user point of view (POV)

4.2 Implementation

The basic structural FSMs and HFSMs are already implemented in the current prototype version. From these basic implementations, we noticed a more realistic highway in one of our scenarios.

We plan to add more features such as built-in traffic light adhering systems, lane follow, and adaptive car follow systems into our final version. These systems would potentially provide a more realistic feel to the traffic around the user as they can adhere to traffic lights, follow and adapt to the user on highway situations.

For AD, we did not plan to implement this into our final version as it is too complex for our scale. Although, having AD cars as independent agents in an educational driving sim such as ours would bring great value to low-cost driving sims and the learner drivers.

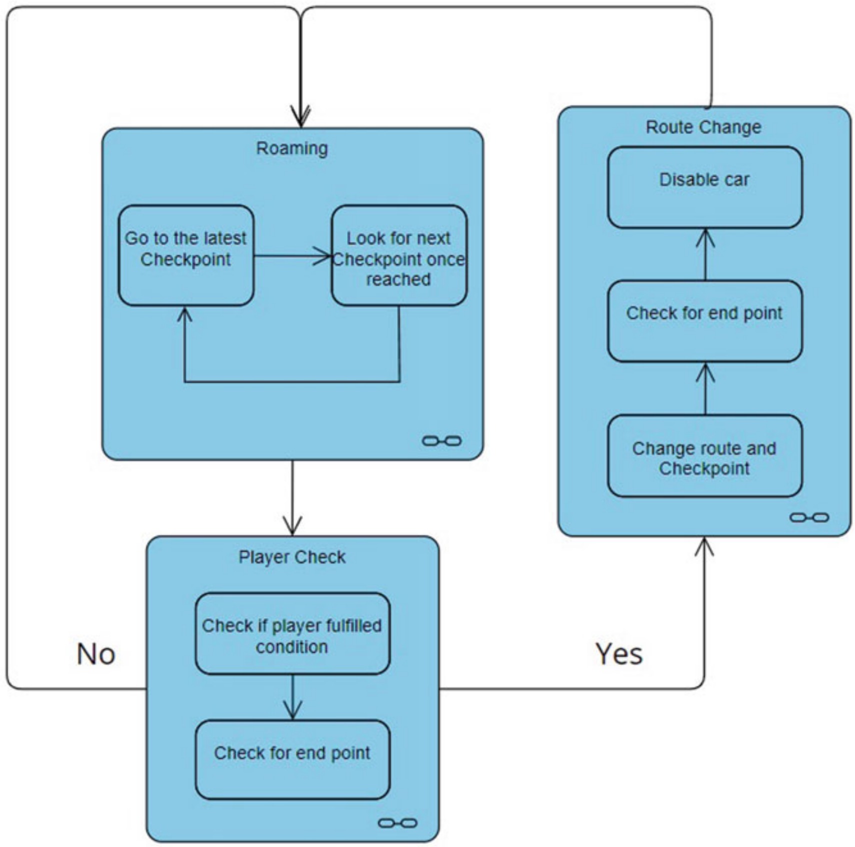

Fig. 10 State diagram of lane cutting NPC

4.3 Potential Effects

As these implementation have yet to be tested. We predict the potential effects of the implementation would be able to provide challenges and really put the users' abilities to the test. The majority of users found adaptive AI in racing games to have a positive effect on their experiences [16]. Implementing HFSMs that can mimic adaptiveness that can provide challenges can possibly have a positive effect on the user's experience. It also can create a sense of realism as the streets and highways will be filled with traffic that roam around independently that we believe will positively impact the user's experience.

Fig. 11 Comparison chart of FSM, HFSM, and AD

Technology	Advantages	Disadvantages
FSMs	Simple to design and tailored to our use case	Too many FSMs for a certain condition will add complexity
HFSMs	Can contain multiple states of FSM in one state	More complex than FSMs, require fine tuning of sub-states
AD	Independent Car agents, able to react and adapt to their surroundings	Complex to design and develop. Unpredictable behaviour of agents

5 Conclusion

We conclude with showcasing that using FSMs and HFSMs in our current project is sufficient to create and mimic a certain extent of Malaysian traffic as shown. Future works related to this project is the refinement of the use of HFSMs in the NPCs and may include the exploration of use of AD technology or any other techniques that can create independent agents that can be unpredictable in behaviour. We would also like to see the gap here in which use of advanced techniques and technologies is used for low-cost educational driving sims and serious games can be explored.

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An Investigation of the Relationship Between Agricultural Price and Its Determinants in Malaysia

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Abstract Prices for major food commodities such as grains and vegetable oils have risen sharply in recent years which have triggered the interest of researchers to investigate the factors of price movement. Understanding agricultural commodity price relationships can help both government and farmers to raise the awareness regarding the price volatility in agricultural market, production costs and other potential risks in the future market. This paper examines the relationships between the agricultural commodities price and the potential price determinants such as exchange rate, temperature, rainfall and covid 19 cases in Malaysia. The investigation is examined by using Granger Causality test and Johansen co-integration test. The estimated results provide evidence a unidirectional causal relationship running from the covid-19 cases to chicken price. Furthermore, there is also empirical evidence of cointegrating vectors exists between temperature and chicken. Overall, the findings have significant implications for predicting the future price of agricultural commodities in Malaysia.

Keywords Agricultural commodities · Price determinants · Granger causality test · Johansen cointegration test

1 Introduction

Even though the price of agricultural products have risen recently, its contribution to Malaysia's GDP declined from 10% in 21st century to 7.54% in 2018. However, agriculture sector is still an important sector in Malaysia's economy. Many

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exogenous factors and variables could be the main causes of such a trend. Hence, risks management has been important in agriculture business, owing to the fact that the uncertainties of agriculture inherent in natural phenomena, weather, government policy, the handling of living organism and other aspect that can impact the price of agricultural products [7]. For decades, price volatility in agricultural market becomes an ongoing issue. Price volatility occurs when the price fluctuations of a commodity become excessive and unpredictable over a short period of time. The instability of agricultural commodities price due to disease outbreaks and adverse weather events, such as flood and droughts will cause supply volatility, impacting producer incomes, endanger the accessibility to food by consumer and market trades [22]. All these impacts may lead to food insecurity, malnutrition, food wastage and starvation [9]. As a consequence, farmers, policy-makers as well as other participants have the urgent needs to have more professional skills and advice in both production and business management to anticipate and mitigate the potential agricultural risks [15]. Studies such as Chen et al. [5] and Chen et al. [26] perform time series analysis and develop forecasting model to predict future events of agricultural markets in Malaysia.

In this paper, Granger Causality Test and Johansen Cointegration Test have been conducted to examine the relationship between rainfall, temperature, exchange rates and Covid-19 positive cases and the selected agricultural prices namely chicken, chili and tomato.

2 Literature Review

There are many variants that can lead to market volatility. Understanding the factors that contribute to the commodity price is significant for the government to evaluate new policies for better plan for plantation and breeding. Determinants of agricultural commodity prices can be categorised into demand-side factors and supply-side factors [4].

From the supply side, the factors are supply shocks, adverse change in weather conditions, climate changes, rising production cost, and high price of energy and energy resources. Besides, demand-side factors include population growth, economic development, income growth, exchange rate changes, speculation and increased production of liquid biofuel [4].

Due to the high dependence of agricultural production on natural phenomena, especially crop production, adverse changes in climate and weather condition can have significant implication to the agricultural market. Climate and temperature changes can affects many aspects in agriculture, such as crops, livestock and fishery. There is optimal temperature for any particular crop for growth and reproduction. If the surrounding temperature exceeds the optimal temperature, crop production will decline [11].

In literature, there are studies investigate the relationship between climate or temperature change and agricultural commodity price. Using VAR methods, Marini