# An Empirical Modelling Approach to a Car Controlling System

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**Abstract**

This paper presents and discusses an EM (Empirical Modelling) approach to a model that embodies patterns of observables, dependencies, and agent of actions that are encountered in experience of driving a car. The EM concepts that used to build this model are presented throughout this paper, so as to discuss the strengths and drawbacks of EM programming.

## 1 Introduction

By comparing the products of EM and traditional programming, EM products have an unusual quality of openness and continuous connection with personal experience. One of the advantages of the EM approach over the traditional programming approach is that the EM systems have continuous dependencies among observables. Once the value of one of the observables has been changed while the model is running, the value of the other observables will also be changed on-the-fly according to the specified dependencies. This model, by taking such an advantage, mainly focuses on how the change of the gear and tyre pressures will affect the engine rotation as well as the speed of a car, by giving a fixed acceleration.

## 2. The instrumentation of a car and EM concepts

In order to monitor the use of the cruise control units, simple representation of the instrumentation (observables) of a car, from the driver's point of view, is inserted into the model. This is the clutch, brake, and accelerator pedals, ignition switch, the engine metre and speedometer, the gear the car is in, and the tyre pressures. Some of the components from the *cruisecontrolBridge1991* project are re-used, such as the ignition switch, speedometer, brake, and accelerator.

### 2.1 Use of EM concepts

Perhaps the most interesting aspect of the EM approach in this context is the ability to experiment with the model in order to intuitively establish beliefs as to the functions and abilities of the car controlling system.

In this way, EM lends itself easily to experimenting with models based on the real world. Definition of observables, which are features of a situation or domain, in this case the domain of a car controlling system and dependencies between these observables, means that changes to observables can cause changes to other observables and the development of the model can be done with extensibility in mind. In this model, the dependencies among the observables are that once the ignition is switched on, the engine rotation speed would reach about 800 rpm. The deeper the gas pedal is pressed the faster the engine rotates and the faster the car travels, if the car is in gear. However, the speed of the car is also depending on:

1) The gear the car is in, as there is an upper and lower speed limit for each of the gears;
2) The pressure of the tyres, as inappropriate tyre pressure increases friction from the ground.

Another concept of an EM model is Agents, which is defined as entities within the domain perceived as capable of initiating statechange. In this case, the only agent is the driver. He/she can adjust 1) at what speed to change the gears; 2) the tyre pressures; 3) the depth of the gas pedal etc while the model is running.

The dependencies of the model lead appropriately to some assumptions to be made in order to simplify the scenario and make the construction of an EM model possible.

## 2.2 Assumptions and abstractions

To make use of EM techniques and provide a working model with time constraints, a number of assumptions must be made. The ignition, clutch, brake, accelerator, tyre pressure, and gear stick are very simplified. The ignition is represented by a square button with text displayed indicating its status. Another abstraction is that of the tyre pressures, clutch, brake, and accelerator pedals, they are represented by rectangles with a bar to indicate the tyre pressure and how deep the pedals are pressed, respectively. Similarly, two square buttons are used to enable gear up and down respectively. In addition, a sunken square is used to indicate the gear that the car currently is in. Because the scope of this model does not include the direction that the car is travelling, only the numbers 0 to 5 are used to indicate the gear, where 0 represents neutral.

# 3 A detailed look at the EM model

In order to investigate the car controlling system, a detailed look into the model is provided in this section. The model can be executed by running the file Run.e in tkeden. Throughout the development of the model, a number of previously constructed related models were reviewed and used, including Cruise Control (Bridge, 1991), Cruise Control (Pavelin, 2001), and Racing (Gardner, 1999).

## 3.1 EM notations

During the development of the model, the EDEN, DoNaLD and SCOUT notations are used extensively.

EDEN is the primary tool for building EM models. EDEN implements a variety of notations, such as DoNaLD and SCOUT.

DoNaLD, abbreviated from Definitive Notation for Line Drawing, enables 2D graphics development inside EDEN environment, such as lines, circles, triangles, rectangle and so on.

SOUT, abbreviated from Screen Layout, is used for managing the layout of the model's screen. SCOUT uses pixels with the top left corner to be the origin to manipulate the position of a certain DoNaLD graph.

## 3.2 Basic experience required for constructing this model

To model a car controlling system, the basic requirement is the experience of driving a car. It is a manual transmission car that is being modelled, so that the experience of gear changing is essential. Furthermore, the knowledge of how the engine behaves and how the speed changes while changing the gear are also the important requirements. For example, the engine rotates slower and the car speed reduces while changing the gear. But as soon as the gear is changed, the acceleration pedal should be pressed and so the engine rotates faster and the car travels faster. If the acceleration pedal is not pressed after changing the gear, the engine rotation and the speed of the car gets slower and slower until the engine rotation reaches the minimum rpm of the selected gear.

## 3.3 The model in action

Figure 1 shows the car controlling system in action under tkeden 1.67. The initial state of the model shows that the global clock is set to 0, the speedometer and engine meter are both set to zero, and all the pedals are placed at the top of the individual bars. The ignition button is raised with the background colour set to green. And the tyre pressure is 30.

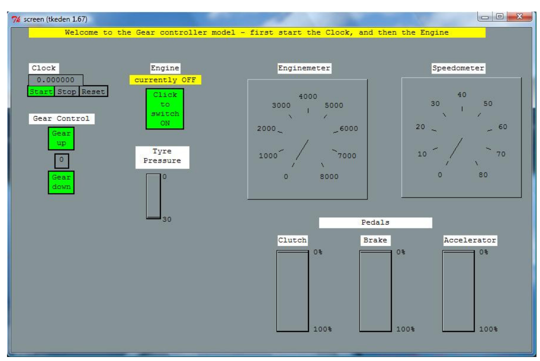


**Figure 1: Car Controlling System EM model**

A different state of the model is shown in Figure 2. The global clock is started, so that the EM model becomes active, the ignition is switched on with the background of the button set to red. The engine rotates around 800 rpm.

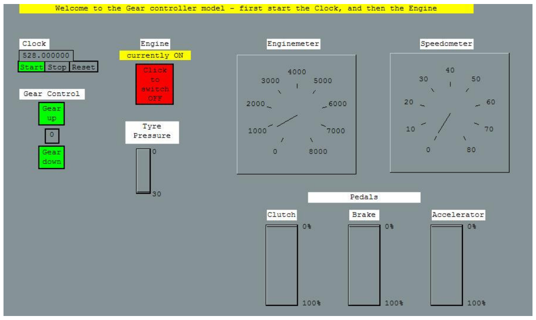


**Figure 2: Ignition is set to ON**

The gear could be changed up and down unless the maximum (i.e. 5) or minimum (i.e. 0) number of gear is reached. The gear changes in four stages once the Gear up or Gear down button is clicked on: 1) clutch down to the bottom and the accelerator up to the top (if it has been pressed); 2) increases or decreases the gear number; 3) clutch up to around 1/3 position, and the accelerator goes back to where it was before; 4) the clutch goes up slowly till it reaches the top.

In addition to controlling the speed of the car by changing the gear, a simulation of reducing or increasing the tyre pressures could also affect the speed of the car.

In Figure 3, the clock is started and ignition is switched on, the acceleration pedal is slightly pressed down, and the car is gear one. The figure also shows that the car is travelling at about 10 mph while the engine is rotating around 1800 rpm.

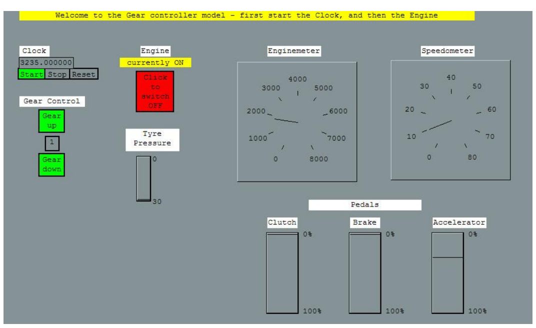


**Figure 3: Model states in gear one**

Figure 4 is based on figure 3, but with the tyre pressure modified to be about 25 from 30. The speed of car is reduced to approximately 8 mph.

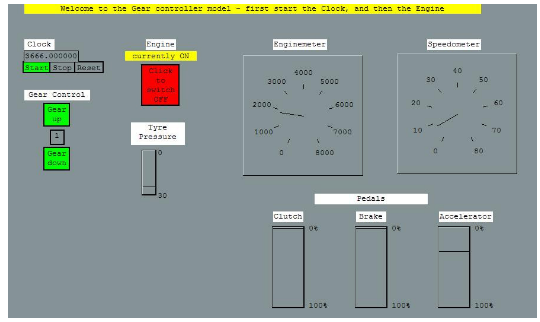


**Figure 4: Model state in gear one with reduced tyre pressures**

# 4 Evaluation

This section evaluates the EM model in three areas. Firstly, an overall evaluation of the EM model in terms of how well the model has achieved the goal of modelling a car controlling system. Secondly, the possible extensions to the model are discussed. Finally, the EM approach is compared with other more conventional approach to the task.

## 4.1 Evaluation of the EM model

Section 3 above aimed to illustrate what my original goal was. Unfortunately, the goal has not been fully achieved due to the time constrain and lack of EM programming skills.

Following the suggestions given by Meurig Beynon, the procedure that controls the speed of the clutch in which it should be released could be simplified by using DOSTE. But I was not confident enough with the limited time available, to learn and try with DOSTE. I therefore continued with EDEN to complete this procedure.

The engine metre and the speedometer are not working properly, the dependencies among these metres and the tyre pressures, as well as the acceleration, brake, and clutch pedals are not defined properly. However, the ignition button does have dependencies with the engine metre and the gears up and down buttons. Only when the ignition is switched on the gear up and down buttons would become clickable and the engine metre points to around 800 rpm; in addition, the gears up and down buttons also have dependencies with the clutch and accelerator pedals, as described in section 3.3.

This model, to some extends, provides a way to learn about and experiment with how to change gears with a manual transmission car. Another criticism of the EM model would be that it oversimplifies the scenario. However, this has already been outlined earlier in this paper, and could be worked on in the future with this paper as a solid foundation.

### 4.2 Possible extensions to the EM model

There are a number of possible extensions in which the EM model could be extended to incorporate additional useful functionality, such as adding:

- An additional observable to model the wing resistance;
- An additional "window" to display the time used to accelerate from 0 to 60mph;
- A slider to adjust the speed of releasing the clutch after changing the gear.

### 4.3 EM approach in comparison to conventional approaches

Empirical Modelling approach is an interesting alternative to traditional Computer Science methods to solve a problem such as this one. Dependency is obviously a solid strength which can be utilised to reduce the effort required in maintaining synchronisation between observables.

However, conventional approaches such as Object Oriented Programming provides good ways to modularise code and increase code maintenance, which might be an area where the EM approach needs moving towards. In addition, maintainability and scalability are the areas in which EM may not be able to perform as well as other approaches. Furthermore, the syntax of DoNaLD, SCOUT, and EDEN are not consistent, which makes EM approach more difficult for new learners.

In conclusion, though, EM has proved to be a very good approach in order to build a model of a car controlling system with many aspects of functionality in a fairly short period of time.

## 5 Conclusions

Empirical Modelling has shown to be a powerful tool, with observables, dependency, and agency as its core concept, in modelling a real world scenario, such as that of a car controlling system. EM model development frees the modeler from having to think about coding issues such as maintaining dependency between observables.


## Acknowledgements

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