Car Interaction at Roundabouts

Abstract

This paper investigates the interaction between cars at roundabouts through the joint use of LSD specifications and a modelling study. In the study, the view of point an external observer is taken to investigate the dependencies in the actions of the various agents, which in this case are taken to be the cars rather than their driver. The paper goes onto discuss how the principals of empirical modelling that are demonstrated and gives a critique of Empirical Modelling in relation to alternative approaches to modelling.

1 Introduction

The focus of this paper will be to study the interaction between cars both approaching and on multilane roundabouts. Multilane roundabouts are a common feature of the road system in the UK and potentially pose drivers a number of problems. The nature of these problems and the causes of them will be studied by using some of the key principals of Empirical Modelling, such as agency and dependency[1].

The final model should be able to be used as an aid for learning and understanding the principals required for safe driving at and approaching roundabouts. The model may also be of use to accident investigators. However, the focus of this paper will be to critique Empirical Modelling and its tools and offer some comparison to more traditional methods of modelling.

1.1 Background

There are a number of situations involving roundabouts that result in an accident occurring between two or more cars. For example, a well known accident is the one where one car goes into the car in front of it on the approach road, having assumed it was going to join the roundabout when it hadn't. There are two key factors that cause such an accident, the first driver not going in the initial gap, either through lack of confidence or concentration and the second driver not looking forward as well as at the oncoming traffic. For an accident like this it is reasonably easy to understand the observations of the two drivers and the assumptions they made that led to the accident. However, on a roundabout there are numerous other sequences of events and assumptions by drivers that could cause accidents that it isn't so easy to understand why they occurred.

1.2 The Process

In Empirical Modelling there are a number of tools that can be applied to explore a set of circumstances. In this study, LSD specifications and Eden will be used. These two tools will be used concurrently for analysis of the roundabout situation. The purpose of LSD specifications in this study will be to help gain an understanding of what or who the agents are from the perspective of the 'observer' used in the model. This then allows investigation into the artefacts and dependencies that influence the agents and so these can be integrated into the model, allowing for a user of the model to explore these dependencies.

2 The Study

This section details the outcomes of the use of the two tools chosen for this study, LSD specifications and Eden. It should be noted that, though the details of LSD specifications are presented first, they weren't developed first and that further progress with either the LSD or model often influenced the next stage of the development of the other. This helped share the ideas generated by one approach with the other.

The LSD specifications can be found in the appendix document which accompanies this paper.

2.1 LSD Specifications

[1] M. Beynon (2001) [1]

For this study two separate LSD specifications were developed. The first LSD specification developed was with the driver of a car as the agent. This helped to with developing an understanding of the situation and factors that influenced a driver's actions. This specification takes a lot of variables (states, oracles and handles) into account and so trying to develop the protocol for the driver was a very difficult task and so has been greatly simplified. Using this specification to develop concurrently with the Eden model would have given greater depth and diversity to the model and would have required multiple observers' views of the situation to do to a satisfactory standard. Such a model would have given a good insight into the experiences of the driver and perhaps an appreciation of the difficulties of judging other agents motions and intentions. In addition to this, the effect of only being able to look in one direction at a time would become apparent, allowing a demonstration of the 'classic' accident described in the introduction.

The second LSD specification which relates more closely to the Eden model takes the car to be the agent with all the drivers attributes merged into that of the car. This removes emotional factors found in the "driver" LSD such as 'being in a rush'. Though it could be said that such a factor also affects the "car" LSD, it was decided that such things not be included to help keep the "car" LSD simpler and more in line with the ideas presented through the model.

2.2 Modelling using Eden

As was mentioned earlier, the second LSD specification (that of a car as an agent) was used to help develop the model. The model is from the view point of an observer external to the actions of the agents and is presented as a top down view of the roundabout and the cars on it. Figure 1 shows the view of the roundabout with two cars on it as provided by the model.

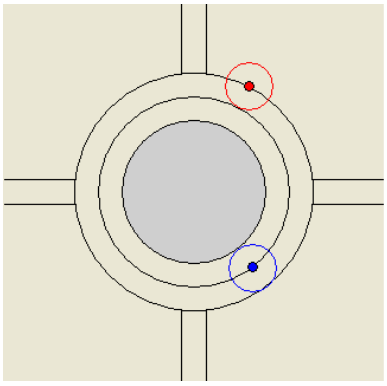

Figure 1: The top down view of the roundabout as used in the model. The roundabout currently has two cards on it. The red and blue dots shown on the model represent cars (agents).

To understand the model, it is assumed that the user has some tacit knowledge of the road system in the UK, such as that the cars will be travelling clockwise and cars drive on the left hand side of the road when approaching/leaving the roundabout.

Model Functionality

The model has been developed to allow the user plenty of scope for interaction with the variables used to control the agents. This allows a user to investigate thoroughly possible scenarios and how they can occur. Figure 2 below shows the table of agent options that the user can configure.

Toggle	App.	Exit	Delay	Speed	Caution	Auto-slow
Red	1	3	0	2.5	70	On
Blue	2	4	2	1.0	40	Off
Green	3	2	1	1.5	50	On
Yellow	3	2	5	2.5	60	Semi

Figure 2: The settings section of the model used to configure the variables used by agents to determine their actions.

The variables in the configuration table are based on the LSD specification for the "car" agent with the addition of the start time delay. The full meaning and impact of the various variables is detailed in the 'read me' file associated with the Eden files submitted with this paper.

Dependency in the Model

The model has been developed with the Empirical Modelling principal of dependency in mind and so effort has been made to ensure that variables are defined such they are calculated based on the value of some variable to which they are linked. For example, it is possible to adjust the angle of an approach road relative to the centre of the roundabout, and the cars will still exit the roundabout to join this new road rather than just going off when they reach a point where an exit road was previously located. This is because the scripts that control if the car can leave the roundabout at a given point are written such that it is dependent on the angle of an approach road. This removes the need for having a static roundabout model and allows for further investigation by a user of situations where perhaps the approach roads are all located within a small area.

Another variable that works using dependency in the model that it is interesting for a user to be able to adjust is the size of the roundabout. This is a useful property of the model as roundabouts do vary in size considerably and the agent needed for roundabouts of different sizes may differ slightly, given that on a small roundabout the agent will look

at all the other approach roads when considering an action, but on a larger roundabout, the agent can only look left.

Though some of the scripts aren't as dependant as they could be, e.g. the layout of the labels used to make up the results table aren't all placed with reference to each other; this doesn't impact the dependency in the model as it is not important, for this to be the case in terms of the model being studied. Additionally, the drawing of a car when its first added to the display uses the execute statement, which though is useful, breaks the principal of dependency, and so placing a car and then moving the approach road it is on will not redraw that car, however, this problem doesn't occur if the approach road is moved before the car is added to the display.

3 Modelling Methods Compared

As mentioned in the introduction, the focus of this paper would be to evaluate Empirical Modelling and its associated tools. Some of the benefits such as dependency in models when using Eden and detailed analysis of variable dependency provided by LSD to help develop the model are apparent from the model developed. However, there are other ways in which the modelling could have been done, such as using an object oriented programming language (e.g. Java) or by using more tradition simulation techniques.

3.2 The Eden Approach

The Eden environment is a powerful tool that combines the definitive and procedural paradigms[2]. In addition to allowing features such as dependency as described above in the modelling section of this paper, Eden has a few other core features to distinguish it for other techniques.

The concept of compiling a program was not appropriate when using Eden. As Eden is more of a scripting tool, variables, methods, etc simply needed to be submitted and would replace the old definitions. This allowed quick testing and refining of the code.

Another feature of the Eden environment was that it didn't type check or validate a reference to a procedure when it was submitted. This was both a good and a bad thing. No type checking and being allowed to do things such switch a variable that hasn't had to be declared from an 'int' to a 'real' was a powerful feature as it gave more freedom to the author of the model. However, this brings with it a set of problems that are probably the reason type checking has been introduced in modern programming languages. A miss spelt variable name would be readily accepted by the Eden parser and take plenty of time to identify as the cause of unexpected behaviour in the model.

In the development of the model three of the Eden environment's distinct languages ('Eden', 'DoNaLD' and 'Scout') where used. Eden also comprised of 'Eddi' and 'Sasami'. Each of these languages has a purpose and they work together quite well, however, it is a disadvantage of modelling using Eden to have to learn multiple syntaxes. This becomes less of a problem as the learning curve associated with modelling using Eden is overcome.

2.2.1 Agent orientated

Though from the model developed as part of this study it isn't highlighted as well as it might be, an important concept in the Empirical Modelling approach is that the models are agent orientated[3] rather than focusing on the overall process. Focusing on the agents involved in the model makes it necessary to identify an observation point for a model to gain an understanding of the experience of an agent who observes from the same position of the chosen view point.

3.2 Object Oriented Approach

One alternative method for developing the model would have been to use an object orientated programming language.

This would allow expandability through modularisation, e.g. adding several more cars to the model would be a trivial task. However, the principal of dependency would not be possible without a function or thread in the background continually updating variables inline with a set of rules. This would be an unrealistic expectation of the program and so it can be assumed dependency in its true sense would not be available. This would mean that doing something like moving an approach road would either require some complex initial programming to allow the user to adjust the model through some interface or a reworking of the code each time you wanted to adjust part of the model. Either way, this would be a much more time consuming and cumbersome process than the one experienced through Eden which does this through updating one variable. Essentially the Empirical Modelling principal of dependency would be lost if an object oriented approach was adopted.

[2] M. Beynon (2001) [1]

[3] M. Beynon (2001) [1]

3.2 Traditional Simulation Approach

The more traditional approach modelling and then simulating a situation is to follow a structure sequence of steps to analyse a particular situation or problem[4]. These steps are to identify the question which it is hoped the simulation will answer, and then develop a model of the situation that simplifies and scales down the problem to a manageable size. This problem is then coded using normal programming methods, often in conjunction with a set of tool written to make the conversation of a theoretical model into a computer model easier. An example set of such tools is SimPack as used at the University of Florida[5]. The model 'executed' to get an answer to the original question. It may then be necessary to revise the question and or model before continuing investigation.

The main advantage to this is that it is a structured approach to a modelling problem. However, the disadvantages are that the method is cumbersome as it requires restarting the process if the 'answers' from the modelling aren't as expected. Furthermore, this method is based on the idea of simplifying a situation, which though can be useful, isn't ideal and not something that should be considered when first approach a problem using Empirical Modelling.

4 Conclusions

In conclusion this project has been quite successful. A useful and interesting model has been developed in conjunction with LSD specifications. In addition to this the model has been developed in a way to highlight the key Empirical Modelling principal of dependency and through interaction with the model a user can also experience how dependency is useful for exploration of a modelling environment.

The development of the model has also given an insight as to the advantages of using Eden for modelling rather than traditional methods or taking an object orientated approach as both of these would fail to provide the benefit of the flexible and interactive environment that Eden presents. Notably this all links back to the idea of dependency and being able to investigate the model while it's "running" by re-scripting functions or variables.

[4] P. Fishwick (1994) [2]

[5] P. Fishwick (1994) [2]

4.1 Author's Critique of Empirical Modelling

Empirical Modelling provides an interesting alternative to traditional computer science methods and provides a varied set of tools.

The notion of dependency is clearly very useful in terms of modelling, and other aspects of Empirical Modelling such as it being agent orientated are interesting and useful alternatives.

One question regarding the use of the current Empirical Modelling tools would perhaps be to ask how scalable they are. Though a wide range of models have been developed, in general the models aren't too complex. Some simulations are extremely large and complex, such as those used for things like weather prediction[6]. In such circumstances the current Empirical Modelling tools wouldn't be adequate; however, this isn't to say that the principals wouldn't be useful.

In summary, the principals and tools for Empirical Modelling are different to other approaches to modelling and are useful enough to justify their inclusion as a future modelling method that should be explored in computer science. This isn't to say Empirical Modelling is a perfect or the best way of modelling, but simply an alternative and valid approach to modelling that has its benefits which where possible should be utilised.

4.2 The Model

Overall the model turned out to well, and would be suitable for demonstrating dependency. Moreover, the model would be suitable for helping to educate road users as to the consequence of their actions by giving them a different view point of the roundabout experience. Possible extensions to the model are discussed in the models 'read me' file.

References

[1] M. Beynon (2001), Introduction to Eden, available from the World Wide Web: http://www.dcs.warwick.ac.uk/people/academic/Meurig.Beynon/MSc2001/MSc92-9/MONDAY/NOTES/mon_tutorial1.htm (accessed 22/01/05)

[2] P. Fishwick (1994), Simulation and Model Execution, available from the World Wide Web: http://www.cis.ufl.edu/~fishwick/book/book.html (accessed 22/01/05)

[6] National Weather Server (2004) [3]

[3] National Weather Service (2004), A Short History of the NWS Warning Event Simulator, available from the World Wide Web: http://www.wdtb.noaa.gov/DLCourses/wes/weshistory.html (accessed 23/01/05)

Full bibliography included in an appendix.