UNIVERSITY OF HERTFORDSHIRE

Faculty of Engineering & Information Science

BACHELOR OF SCIENCE DEGREE IN
MULTIMEDIA TECHNOLOGY

Project Report

Big Dave's Little Trains (A Virtual Control System for a Model Railway)

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Abstract

Currently, the Model Railway industry is a rather backward type of cottage industry that needs bringing up to date. This project outlines a new method of controlling a model railway that will bring this outdated industry a step closer to working effectively in the 21st Century.

The experts consulted about this project (The Old Barn Model Craftsmen) consider the output to be a useful tool in modelling and are keen to add it to their catalogue.

Acknowledgement

There are a lot of people who contributed to this project in some way. First and foremost I would like to thank my father for his tireless aid in helping me

i. Obtain cheap parts for construction of the layout.

ii. Being my main consultant at the Old Barn Model Craftsmen.

iii. His tireless work in helping me both with the tedious and troublesome electronics and his work on the scenery of the layout on which I couldn't have done without him.

Without his help this project would have been a complete failure.

Secondly I would like to mention the other expert involved. These experts are members of the Old Barn Model Craftsmen and are mentioned throughout the project. The other member consulted was Mr. Brian Taylor, head of the company. He was also a valuable aid.

Next in line for a great deal of thanks is my project tutor, Professor Talib Alukaidey. I would have had great difficulty with a lot of the software if it hadn't been for his help and timely emails. Whenever I had a problem, an email suggesting something always seemed to appear before I even asked him. Finally, the man who wrote the original copy of the "lprout.exe" program used in this project. I do not know who he is but without the program, the project would not function.

Contents

1. Introduction and background

This project was conceived to control a model railway from a computer, something that had never been done before. This meant offering an easy and effective way of controlling a physical layout through the computer.
To understand all the concepts used, first it is a good idea to know a little about the background of the involved devices.

The model railway

Railways themselves have been around for a long time and the nostalgia of the steam railway has become widespread since its decline. There are full size railways in operation dedicated to the preservation of steam railway. However, it is not practical to own one of these and have in the home unless you are a billionaire. To this end, model railways appeared and flourished. Today, large companies exist to offer toys for children and detailed replicas of all kinds of railways, not just steam engines. However, companies that build model railway layouts tend to be still orientated around the classic style of cottage industry. Although electronics are used in the layouts, the controls are simple knobs and buttons. This can cause very complicated control panels, especially for the bigger layouts. The layouts themselves tend to be very detailed and very expensive, thus only enthusiasts or rich clients tend to buy them. However, this does not stop the common man from having his own layout. Companies such as Hornby offer affordable products to build your own layout. They now also offer computer software to design it and tell you everything you need to make it, which they can then supply.
There are several scales of railway used in the U.K. "N" gauge is the smallest and it operates on a 9mm track. The scale of the engines is 1:148 (British) or 1:160 on the continent. This is approximately 2mm per foot in real life. "Double O" gauge is next with a scale of 4mm per foot and a track gauge of 16.5mm. "O" gauge is getting bigger still with a scale of 7mm per foot. G scale is the biggest used widely and this is mainly for garden railways.

The Computer

This will not be a history lesson on the origins of the computer. This section will explain a little about how computers have been used in a similar way to this project.

The computer has many ports for sending and receiving information. The keyboard plugs in to the computer and allows it to receive an input from the outside world. The printer plugs in and acts as an output through either the parallel port or the universal serial bus. The terms are computer jargon for defining what type of port to use. Input/output (or I/O) cards have been around for a long time now and are used widely in industry as a conduit to control machinery from the computer. There are many examples of this. Precision engineering uses computers to control machinery, the design is put in and the computer then tells the machine how to make it. For the purposes of this project, nothing so extravagant is required but the general principle is the same.

2. Aims and Objectives

Basic Aims and Objectives

This final year project is aimed to create a control system for a model railway layout. It will enable the end user to set up and plan all of the routes of a train both entering and leaving a station with a minimum of user input. The system should also allow for control and movement of different trains with sections of the track isolated. This would allow for changing the engine to pull the train or for storing extra engines in sidings.

Detailed Overview

To create this virtual model railway control system, first a physical layout would be needed, primarily for testing and finally for demonstration of the working project. This must be of a suitable size to balance cost, size and complexity. This will be the first objective to complete. Once this is completed, all electrical connections must be wired. The main elements used will be relays and solenoids to change the points (known as point motors) and power for the locomotives that would actually run on the layout. This will most likely consist of a mains powered transformer and rectifier to change the mains voltage to a 12V dc variable output. Next comes the computer interface. The first problem to deal with is deciding which port to enter through. Two way signals may be required – one from the physical track telling the computer where trains are and how points are currently set, and, one from the virtual railway inside the computer to the track to control the trains and to set the points correctly. The next problem is how to write the software to perform the actual control. This is the greatest problem so far and will have to be looked into to find the ideal method for control. Macromedia Flash or Director would seem the most likely choice using the keyboard interface as the link between the two devices. Key presses can tell the computer everything that it needs to know about the layout and the L.E.D.s on the keyboard show that the computer is capable of sending signals as well as receiving. It may also be feasible to use the parallel (lpt) port of the computer. This should be left open to consideration as well. With expansion on this and research into keyboard architecture, a new device could be made to interface the railway to the computer, using one of the previously mentioned programs to control it.

3. Research

To complete this project, a lot of research would have to be undertaken to learn about the principles of the system.

Physical Layout

The first place to look was in books that were borrowed from the experts. A list of these can be found in the appendix (see appendix B 1.1). The second area of research would be consulting the experts at The Old Barn Model Craftsmen.

Virtual Layout

Due to the fact that this was a new idea, my experts were unable to provide any assistance with this part of the project. This meant that the best source of knowledge being the Internet. There was one book that was unavailable and may have proved very useful in this project. It comes highly rated by many people and may prove useful in further development of this project. It is entitled “Controlling the Parallel Port” by Jan Axelson. However, as this was not available, it was not used. Please see appendix B 1.2 for the list of websites visited.

4. Design

Physical model railway

It was necessary to create a small layout for use in the demonstration of this project. To this end several considerations must be made. The layout should be

i. Realistic

The layout should conform to standards used in real life so that it was an accurate model representation rather than a toy.

ii. Portable

The layout must be of a suitable size and be robust enough to be transported around. This is so that it can be brought in to university for use in the demonstration.

iii. Attractive to look at

In order to make a good impression with all those looking at it, it must be suitably decorated. First impressions are everything when presenting a project.

iv. Functional

There must be enough on the layout to demonstrate that the computer is indeed capable of running it and also bigger layouts.

v. Cost effective

A usual railway layout of the size required would cost around £1000 ready built. Obviously labour would be a large part of this and as this was a project, I would undertake the work. The parts would still amount to around £200 so the best way to do it would be to sift through a professional companies thrown out bits.

To this end the experts were contacted to find a realistic, suitable design. In conjunction with them the design used was reached (see appendix fig. 1.1).

Virtual model railway

After due consideration and research of what had been used as a control interface previously with model railways, a graphical user interface based upon a plan of the physical layout was decided on. This meant drawing out the layout on the computer and then positioning buttons accordingly.
The first thing to do now this has been decided is to choose the package to use. The two obvious choices that were available were Macromedia Flash and Macromedia Director. For this project Flash was chosen, but Director would probably do just as well. A separate drawing package would be needed to draw out the GUI and then the controls would be added in Flash. A separate piece of code would control the parallel port, activated by Flash's Action Script.

Electronics

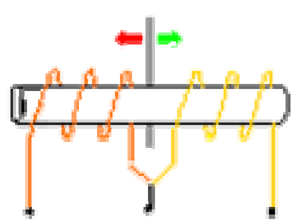
This is an extra part now that had to be considered. This project will not only require a virtual and physical layout to be created, but also they would need to be linked together by an electronic interface. The majority of this section was taken out of a book. This is mentioned in Appendix A and it was probably the most useful book used. It is "Wiring the Layout" by Jeff Geary. This book offers circuit diagrams of everything needed for a layout to be controlled by a discrete output from a device. This is something that the parallel port of a computer can readily supply. This meant that the parallel port was the best choice for the control of the system. This meant that the majority of the design work was done for me in this book. The final drawings and the initial ones taken out of the book can be located in Appendix D.1.1 and 1.2.

5. Implementation

Physical Layout

The first thing to do was to build the physical layout. To do this, a baseboard is needed. Fortunately, there was a spare one available already made. It had been constructed by the experts for a job that never took place and was now cluttering up their workshop. It soon disappeared into the workshop used for this project. A few modifications were made to make it the right size and a join made in the middle to make it more portable (see Appendix C Fig1.1). Now a baseboard was ready, it was time to lay the track. It is a good time to mention that the track plan was mainly designed around the size of the available baseboard. Usually, a plan is made and the baseboard designed around it. If money were no object then this project had unlimited monitory resources then it would have been done in this way. However, as this was not the case the baseboard available dictated the design. Thus, track was laid on the baseboard and the design used fitted the best (see Appendix C Fig1.2).

Once the track had been laid properly and pinned down, the next stage was to add the "point motors" (basically 2 solenoids) to change the points. These can also be seen at the bottom of Appendix C fig1.2. Below is FigA, a diagram of how they are wired and how they operate.



FigA

There are 3 connections. The middle is the common. The other two terminals are the live connection. They are either on or off and are switched by the power supply, depending on which way the point has to fire. All the points have the common connected together and the other wires are fed in to the control box. There a very large capacitor is used to "fire" the points. This is called the capacitor discharge unit (CD or CDU).

Before moving on to the technical electronics side, it is good to talk about what is seen on the layout. This was all added right at the end of the project as time allowed. Appendix C fig1.3 to 1.6 shows a brief pictorial view of the scenery and decoration being added. This is mainly artistic work and this was mainly done either under instruction or by a third party, as it would be very time consuming to an inexperienced artist.
Back to the technical side now. With the majority of the layout done now, there was the electronics to consider. As mentioned in the design work, the drawings shown in Appendix D were taken straight out of the book. These were not quite what was needed for this project as they only offered 4 outputs instead of the 16 needed. Also, the circuit could not be doubled up completely as there was a limited availability of some of the expensive chips. There were only binary decoders available with 4 inputs and outputs, not 8. This meant that 2 had to be used. As they are not aware where they are put in the circuit, only certain higher numbers could be used. For example, 17 could not be used as pin 5 would be on and pin 1 would be on. These pins are on different chips; thus the circuit would think there were 2 inputs. The final circuit plan can be found in Appendix E. Appendix F shows all the components needed to create the circuit, together with the price and RS catalogue number.

The circuits were soldered by hand onto "veroboard" instead of proper printed circuit boards (PCBs). This was because of the time and expense of producing proper PCBs (There was no acid available). Once this was completed, the power supply was mounted in a proper metal case to keep in line with regulations when dealing with mains power and the rest of the circuitry mounted in a convenient box.
Now would be a good time to mention the opto-isolators used in the circuit for the computer output. These are special sealed chips that transfer the information as light so as not to expose delicate equipment such as the computer to high voltages should there be a problem with the circuit. These

contain L.E.D.s (light emitting diodes) and a light receiver (not sure what, probably an L.D.R. (light dependent resistor)).

The circuits used to control the layout from the computer are fairly complex and take a lot of time to build, thus, in the mean time a small display unit is useful to check outputs from the computer whilst constructing the software. This can be made easily with 8 L.E.D.s and some wire. The one used in this project was mounted in a box for convenience and this would be recommended to ensure no short circuits. The L.E.D.s are connected via a D-type connector to the parallel port of the computer. The other pole is connected to the ground output of the computer. This unit displays the binary output of the computer visually and can be used to test software.

Virtual Layout

There are two parts to the creation of the virtual layout. Basically, they are the easy part and the hard part. The easy part will be dealt with first. This is creating the graphical user interface. The first thing to do here is to create a scale drawing of the layout, preferably including all the scenery so the user has an aesthetically pleasing but accurate view of what the physical layout looks like. Any good design package is good for this, but for this project an old program called “Designworks” was used. Macromedia Freehand or any such program may be better as it is more up to date. Experience in the program really dictates the choice of software to use and because of this, Designworks was appropriate. Once this is done, the image must be imported into flash to be used as a background. The next step is to insert appropriate buttons. The minimum needed is 2 buttons for each point. As well as this buttons to control the train are needed. “Go” and “stop” are needed both in forward and reverse directions, meaning that another four buttons are needed. Once these are in place they need to be configured using ActionScript to perform the desired tasks. The ActionScript needed sends the program to the frame u need as following:

On(press) { gotoAndStop(2)}
This will send the movie to frame 2 and stop it when the button is pressed.

Now comes the second part of the virtual layout. This is the hard part. Firstly, it is not possible to send or receive information from the parallel port in JavaScript or VBScript, which are the 2 languages recognised by ActionScript. It is necessary to run an external program. This can be done in ActionScript as follows:
On(press) { fscommand(exec,"prrogram to run.exe") }
This is also not too tricky. The tricky part is to either find or write a program that controls the parallel port. After extensive research in C, Java and C++, a program was found written in Pascal that would suffice. It was a simple DOS based program that required a parameter in the command line. It is called "LPTOUT.exe". To send "1" to the parallel port "lptout 1" should be typed at the command prompt. This meant that in the Windows operating system several versions of the program must be made and the command line edited on each one to send a different signal to the port. This proved very tricky in later operating systems and in the end Windows 95 or Windows 98 First Edition proved to be ideal operating systems for running this project. These older systems make a shortcut to the program that is run instead of the original program through Windows. This means that it is possible to have different programs sending different signals to the parallel port. The address for downloading "LPTOUT" can be found in Appendix A, but is included here, as it was such a vital piece of getting this project to work.

http://splat.foo.is/electronics/parallel_output.htm

Not only does this site have a ready to use compiled version of the program, but it also has the code in Pascal, C, Assembler and Basic. These other languages would work just as well, but then there is the problem of compiling. Now all that is left to do is set up the shortcuts to the numbers required to operate the physical layout (0 to 255).

6. Time Plan

Time management is important to keep the work on schedule and meeting deadlines. The plan below shows guidelines that should be met in order to keep the project running smoothly without any of it being rushed.

Breakdown of Time plan

Due to several problems with the time plan, it could not be entirely stuck to. This was mainly for 2 reasons. Firstly the problems with the software in getting the computer to send a signal to the parallel port and secondly with the electronics as they didn't quite work as predicted. The electronics will not be mentioned in too much detail as the final schematic shows a working circuit after all the problems had been ironed out. However, the other problem was that of finding the program for controlling the parallel port. The time plan did not allow enough time for this and thus everything following the interface (after week 26) was considerably put back. Most of the testing, in fact, was completed the day before the project demonstration. Fortunately, it all went as planned and there were no problems then. However, it could have gone completely the other way and the project would have been a failure. Perhaps more research into the system would have been useful.

Week 1 to week 3	Arrange title of project and sort out formalities and details.
Week 4	Complete feasibility study
Week 5 and 6	Design plans for construction of physical layout.
Week 7 and 8	Start construction of layout, keeping well-documented reports of progress for use in final report and seminar presentation.
Weeks 9 and 10	Start design of user interface for the virtual layout in relation to the physical one.
Week 11	Prepare and present Seminar.
Week 11 to 18	Complete physical layout and begin work on interfacing the virtual and physical layouts together. Complete the virtual layout so that it is a good representation of the physical one.
Week 19 to 20	Keep working on the interface, prepare and present report to external examiners.
Week 21 to 26	Complete interface from virtual to physical layout.
Week 26 to demonstration deadline	Testing and finishing touches, user's manual (scenery for layout – aesthetics and preparation for transport of layout for demonstration)
After demonstration	Compile report from all information gathered over the building of the project.

7. Risk Assessment

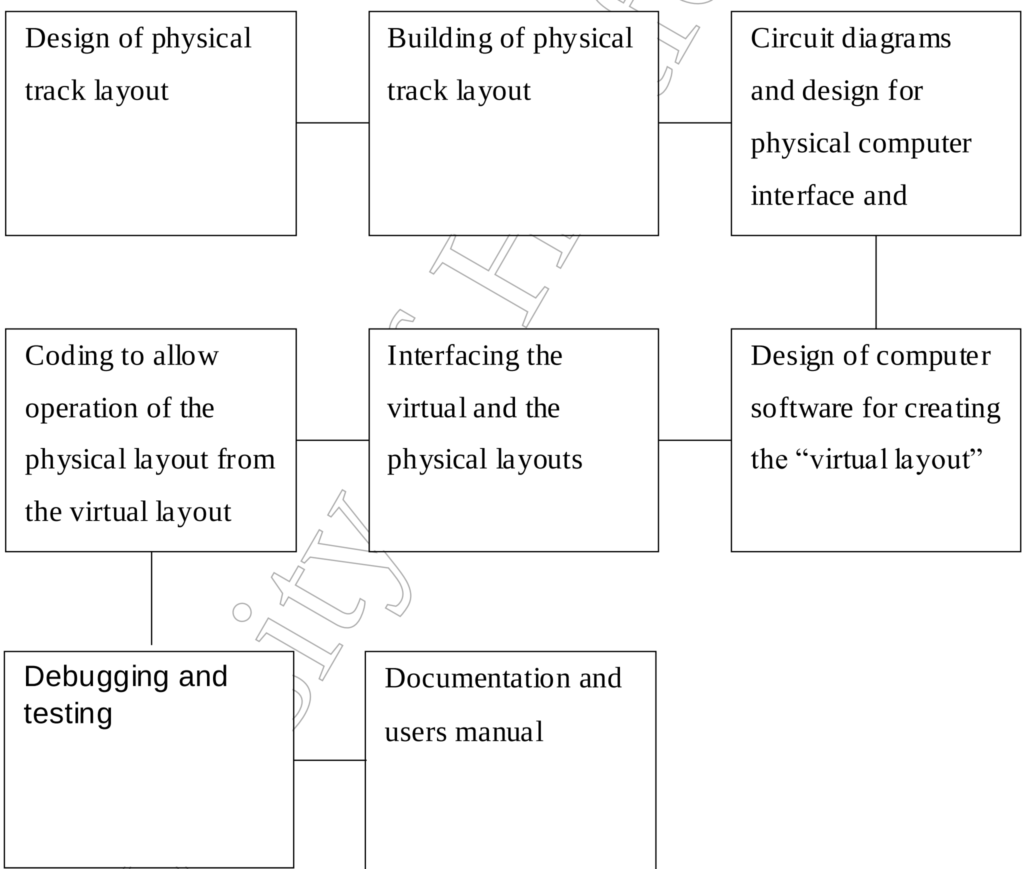
The main risk for this project is the bare rails of the physical layout of track. When an engine is running, these rails will be live with a maximum 12V direct current across them. Touching a rail whilst a train is in motion could result in a small electric shock. There will also be moving parts in that the trains themselves will move and the motors inside them will turn as well. These are ready built models that have passed a standard of safety. The electronics were tested to ensure both functionality and safety. The final moving component is the solenoid contained in the point motors. This is of minimum risk. Lastly, the risk of plugging the layout into a computer, there is little to no risk here, as the device was fully tested prior to demonstration and was optically isolated from the computer.

Risk	Value of Risk (/10)	Precautions	Acceptability
12V direct current across physical train tracks.	7	No one must touch the physical layout except the project demonstrator who has knowledge of safe parts of the track.	Acceptable as long as precautions are abided by.
Moving Trains and other moving parts.	2	Keep everyone at a safe distance from the physical layout.	Acceptable as long as everyone stands back (or stays seated). Point motors are negligible risk.
Electronics and connections to the computer.	3	This will initially be a risk to the test computers, however it will only be tested on my personal computer to ensure the safety of all university systems. When the project is demonstrated there will be little to no risk.	Acceptable as long as all testing is successful.

The highest level of risk is the voltage across the rails of the track. As long as it is not touched by anyone other than the project demonstrator there is no risk. There is no virtual risk with the software to be used.

8. Block Diagram

Below is a block diagram showing the stages of construction of the layout.



Breakdown of Block Diagram

This is the block diagram suggested in the feasibility study. It was given as rough guidelines, but these guidelines proved to be mostly accurate. However, they were flexible in that sometimes more than one part was being worked on at once.

9. User Manual

The next 4 pages contain a standard user manual issued by the experts at the Old Barn Model Craftsmen to all clients. It has been modified to accommodate the layout used in this project and to use the unique control system. There is technical information in there as well as just operating instructions as it is important that the client is aware they have got what they paid for. This includes a specification of all that has been made.

10. Costing

This project is not a cheap one to undertake, even doing everything “on the cheap”, more money was spent than anticipated. The following few pages offer a detailed pricing of:

i. How much the layout would have cost if built by the professionals using their system of pricing (Excel spreadsheet).

ii. A sheet detailing the actual costs in building this, including all second hand parts used.

iii. A components list of all the electronics and, where applicable, the RS part codes and prices.

It is clearly visible that if the project was to be undertaken again by another person that the costs would really mount up to well over £1000.

11.Further Work

This project, although it fulfils all of the aims, is not entirely complete. Further work would be to include sensing equipment on the track to:

i. Relay back to the computer the position of the points, this will show whether they have changed or not when they are supposed to and allow for animation of them on screen in the virtual layout.

ii. Show the position of the train. With well placed sensors the virtual layout could show the train going around the track just as it is on the physical one. This will take a lot of coding and a lot of more complicated electronics, but the results will really enhance the user's experience.

Finally, it would be nice to have route settings on the virtual layout. This was originally the plan for this project, but, unfortunately, due to problems with getting the computer to wait for the CDU to recharge, it was not possible to accomplish. Route settings would get the points change one after the other to select a route automatically for the user. This would be very useful for bigger layouts with lots of points.

12. Testing

To ensure a stable system it must be tested. There were 2 stages of testing used in this project. The first was to test the software and this used the box with L.E.D.s to show the output from the parallel port in binary. This tests the outputs from the program created in flash. When a button is pressed on the GUI, this piece of apparatus displays the outputted result.

The second part of testing was with the entire project complete. This was to test that the layout responded properly to the incoming signals from the computer. There were a few problems with this to be rectified. The first was a simple one in that the trains were not running properly because the track was dirty (and second hand). This meant that the trains could not pick up power from the rails effectively. This was resolved with a very fine grade of sandpaper being gently rubbed over the rails.

The next problem was that the power was not really enough to get the trains moving at a decent speed. However, there is a pot in the speed control circuit that can be used to adjust the top speed. This was turned up and this resolved the problem.

Once these issues were resolved, the project worked as it should with no problems.

13. Evaluation and Conclusion

In all, this project was a success. It was a worthwhile undertaking as the end result is a useful product rather than a useless piece of software that would never be used again (a personal aim). There is room for further development, but as a prototype it functions more than adequately. The software was not quite what had been planned as it used stand alone programs to send the signal to the parallel port. This meant that it was not as robust as it could have been. There was a lot more work on the electronics than previously expected as well, meaning that a lot of time had to be spent both making the circuits and debugging them once they were constructed. This was mainly due to a limited knowledge of electronics and not being able to find the exact specification of the needed circuitry.

If this project were to be done again, then more time should have been devoted to it. This may prove difficult as a final year project as many other subjects had to suffer when this was made due to the sheer mass of work. However, the end results are well worth the hassle and work in undertaking it. It is possible to conclude that the project was a complete success as it fulfilled all of the aims and objectives.

Bibliography

The websites and books used are contained in Appendices A and B.