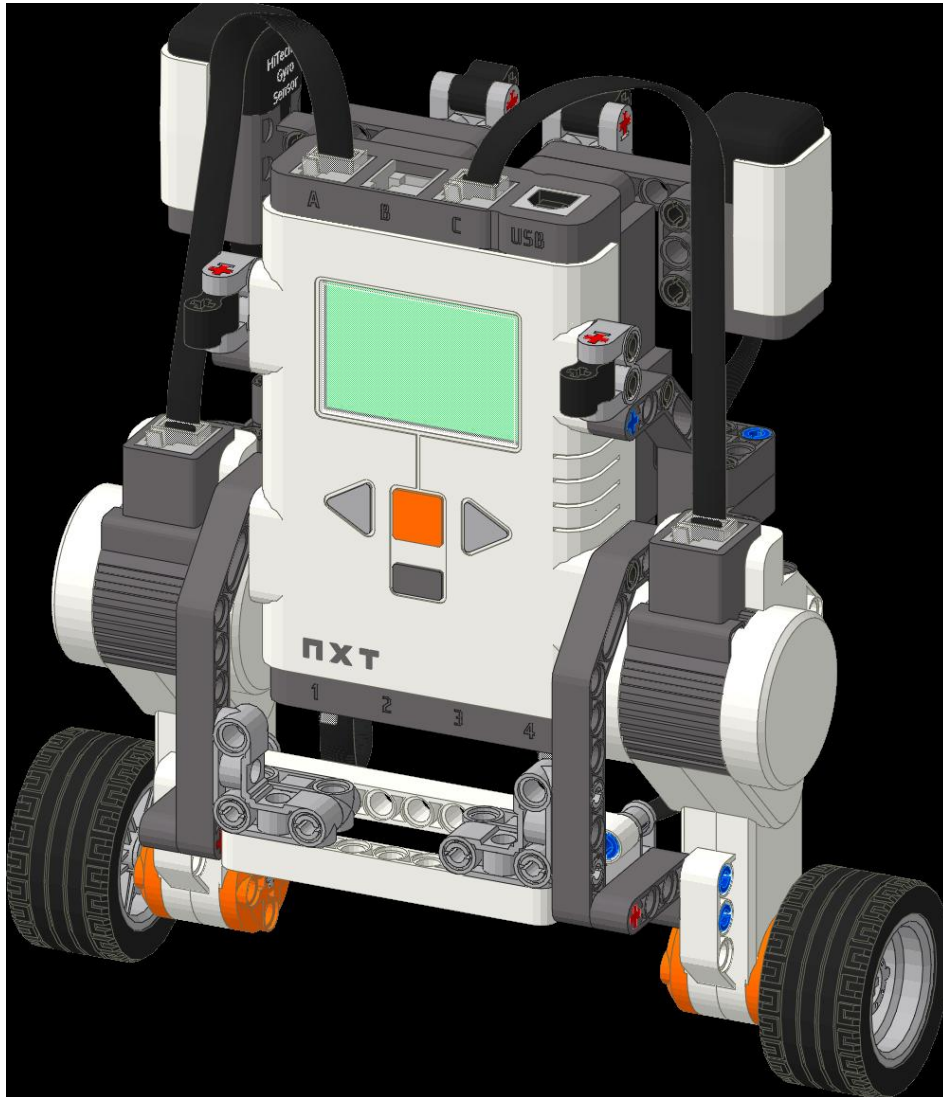# LEGO MINDSTORMS SEGWAY PROJECT REPORT

BUILDING A SEGWAY USING LEGO® MINDSTORMS® NXT 2.0 TECHNOLOGY

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DOCUMENT KEY

Folder name

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Hyperlink

1. INTRODUCTION

The aim of the LEGO® Mindstorms® Segway Project was to use LEGO® NXT 2.0 technology to design a Segway-like self-balancing robot. This document provides the report of challenges and findings encountered during the design of the LEGO® Mindstorms® Segway project.

2. KIT AND TOOLS

A variety of tools were used during this project, both in terms of hardware and software:

- LEGO Mindstorms kit with basic sensors and motors
- LEGO Mindstorms NXT-G software
- HiTechnic Gyro Sensor
- MATLAB/Simulink and additional MATLAB tools
- Cygwin
- GNU ARM
- NeXTTool
- BricxCC
- Standard and enhanced firmware
- Driver v1.20 and Fantom driver

3.METHODS

The main initial challenge was to decide which method to use when designing the LEGO Segway.

MATLAB & SIMULINK SOFTWARE

Early on in the project, a link was established to develop the LEGO Segway using MATLAB, Simulink and additional plugins to design the LEGO Segway. This idea emmerged after viewing a YouTube video demonstrating the capabilities of a LEGO Segway developed by **Yorihisa Yamamoto** (video [here](#))**.** Later on in the project it was seen that designing such a system on the Windows Vista platform caused some difficulties which will be discussed later.

BRICXCC PLATFORM SOFTWARE

There was a possibility to design the Segway using software called BricxCC developed by John Hansen, which was an enhancement of older software called RxCC, originally designed by Mark Overmars to enable programming of the LEGO Mindstorms RXC bricks. The BricxCC software works as compiler and downloader to any LEGO brick, working much like AVR-Studio, and tolerates languages such as C/C++, Pascal, Forth, NXC/NBC depending on the type of brick to program. More information can be found [here](#)

NXT-G LEGO MINDSTORMS SOFTWARE

The LEGO® Mindstorms® comes with programming software - NXT-G. It's a platform that, much like Simulink, uses blocks to edit and compile a program for your LEGO Mindstorms' brick. This method was also considered because it is much simpler to use than the above 2 methods, and also more reliable because it is based on approved-LEGO programming methods and of no risk to damaging the LEGO NXT brick.

4. RESEARCH

PHASE 1: MATLAB/SIMULINK

There were many research steps involved in the design of the LEGO Segway. Initially, the MATLAB/Simulink method was opted for reasons discussed in the previous section. An environment had to be set up in order to enable programming and designing of a system for the NXT brick. Much of the work in this domain, related to MATLAB/Simulink programming of LEGO bricks was developed independently of LEGO itself.

THE EMBEDDED CODER ROBOT NXT (ECROBOT)

The ECRobot NXT is a method which enables Model Based Design using LEGO blocks and simulation in Simulink. It can be installed using the EmbeddedCoderRobotInstaller folder. Once completed, LEGO Mindstorms blocks can be found in the Simulink window. This programming method allows for the most freedom but is also the most time-consuming.

PROCEDURE

For the MATLAB/Simulink method to function correctly the environment first had to be set-up through the installation of additional tools such as Cygwin and GNU ARM, and then the LEGO brick firmware had to be updated to an enhanced firmware. Once completed, the designing could take place and demo models could be opened (located in the Modelsandsamples folder). Once completed, sample Segway files were run on Simulink for simulation and download to the NXT brick (LEGOSegwaySimulink folder)

SUCCESSES

1. MATLAB R2009b was installed and used, and this version was entirely compatible with the project environment of the NXT LEGO brick.
2. Documentation was easy to use, and installation of the environment was straightforward for the most part.
3. Simulation blocks were successfully installed onto Simulink

CHALLENGES AND DIFFICULTIES

Many problems (mostly minor) were encountered during the MATLAB/Simulink research and programming phase:

1. Enhanced Firmware needed to be installed onto the NXT brick, which cause some difficulty to ambiguous firmware installation methods and software
2. Installing Cygwin caused some difficulties at first because of proxy issues, and often installation procedures were not very clear on the website
3. The final MATLAB installation file could not be completed due to an error in file path saving. This is due to Vista blocking out software trying to save files to the C drive in order to reduce computer problems. This was only a minor issue but it meant that the

ECRobot environment installation had to be rerun each time MATLAB was opened as the path was not saved to the disk permanently.

4. Simulation was not functioning because it needed to access and write files to the C drive in order to run, access which was automatically denied by Vista platform.

DESCISIONS

From experience in runtime and programming with MATLAB/Simulink, it was decided that this method could not be used for the main reason that Vista would not give the software access to the C drive. Hence, the research continued for another method to program the NXT brick.

PHASE 2: BRICXCC

After internet research, the HiTechnic website, manufacturers of the Gyro sensor bought for the LEGO Segway project, a new programming method was established, that of BricxCC. It is software that enables the programming of various LEGO bricks using C variant coding languages, specifically NXC/NBC for the NXT brick (Not eXactly C/Next Byte Codes).

NXC/NBC

NBC (Next Byte Codes) is a simple programming language that can be used to program LEGO NXT bricks. Not eXactly C (NXC) is a C-based programming that can also be used to program the NXT brick. The language guides are included in the NXCNBCCodinglanguage folder.

PROCEDURE

The BrickxCC software first had to be installed in order to have a GUI for the programming of the LEGO Mindstorms brick. Due to inexperience in both NXC/NBC languages, a sample program was obtained from HiTechnic (in the HiTechnicLegoSegway folder).

SUCCESSES

1. Enhanced firmware was successfully installed onto the NXT brick and changes could be reverted at all times
2. BricxCC was a successful compiler and no interface or software problems were encountered
3. Connection was always successfully established between BricxCC and the NXT brick

CHALLENGES AND DIFFICULTIES

1. Inexperience with coding meant that the sample coding could not be modified successfully. Initial HiTechnic project was using an Infrared receiver, and coding could not be modified to only include the gyro sensor

DECISIONS

BricxCC is a great and versatile way to easily program the NXT brick, but specific coding languages used take extra time to get used to. For the purpose of this project, another method had to be used in order to advance but BricxCC is definitely a more practical way to program the NXT brick.

PHASE 3: NXT-G

NXT-g is the "default" LEGO Mindstorms software, included with the initial kit, to enable the user to program and use the NXT brick.

PROCEDURE

The LEGO NXT-G software had to be installed using the CD provided with the kit. Drivers did not need to be installed as this had already been done in previous stages of the project. Once again, a sample .rxe program was downloaded from the HiTechnic website (in the HiTechnicLegoSegway folder) and compiled to the NXT brick

SUCCESSES

1. First successful download of a program onto the NXT brick
2. Success in building self-balancing robot

CHALLENGES AND DIFFICULTIES

1. NXT-G program is difficult to understand when it used for complicated programming task. Despite being the simplest method to use, it is still very time-consuming and often confusion arises due to too many commands on screen
2. Despite successful code, the downloaded program is very unstable and can be seen when the Segway is standing. The equation is very difficult to optimise under NXT-G software conditions.

5. CONCLUSION

The LEGO Mindstorms Segway was an interesting challenge, more because of the Physics involved in such a device (full description of inverted pendulum theory in NXTway-GS Model-Based Design.pdf file in the LEGOSegwaySimulink folder). Research led to 3 methods of exploitation of the NXT brick being obtained which, despite unsuccessful tries, means all discovered methods can be used to fully develop the NXT brick for prototyping, programming and further projects. Optimising the balance equation would have been ideal, but it easier to do under a simulation platform such as Simulink.

6. APPENDIX

For more information on LEGO® Mindstorms®, visit:

http://www.mindstorms.lego.com/

HiTechnic website where NBC code and NXT-G files were obtained. Extra sensors can also be purchased:

http://www.hitechnic.com/

BricxCC website, support for NXC/NBC and other tools:

http://bricxcc.sourceforge.net/

Yorihisa Yamamoto's Simulink Segway project on MATLAB Central:

http://www.mathworks.com/matlabcentral/fileexchange/19147

ECRobot Environment:

http://www.mathworks.com/matlabcentral/fileexchange/13399

Nxtosek website:

http://lejos-osek.sourceforge.net/

Cygwin:

http://www.cygwin.com/

GNU ARM:

http://www.gnuarm.com/