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Self-Correcting Autonomous System

a dynamic measure-and-adjust system utilising arduino microcontrollers and sensors

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# Basic Information

The origins from which this project stem are that of the BigDog project[[1]](#footnote-1) currently being developed by the US-based robotics firm, Boston Dynamics – a robotic quadruped that is capable of running, walking, and maintaining its balance in rugged terrain. BigDog is capable of this feat due to its very adaptive internal gyroscope system (Raibert, 2008) To this end, I proposed to my project supervisor, Dr. Jacob Howe, a system which; like BigDog was able to adapt in order to maintain balance.

## Problem to be solved

The proposed system will make use of an Arduino Accelerometer Module (a sensor which measures orientation on the X, Y, and Z axis) and a stepper motor connected to an Arduino Due Microcontroller Board. The system will act as a self-correcting scale – actively correcting itself to bring itself to a horizontal orientation. The project design would be similar to that of an airplane’s autopilot module – adjusting to correct itself based on its current system state.

This system could, if successful, theoretically, be used as a gyroscope to maintain larger systems to keep them oriented to user specifications.

## Project Objectives

The objective of this project will be to learn, design and construct a system which is capable of physically adjusting itself in response to outside stimuli (an active change in its orientation). A successful completion of this projects stated objectives would be one wherein the proposed machine can consistently and accurately adjust its orientation to the user-specified angle. The following sub-objectives will need to be met in order to complete this task.

### Learning the Arduino Platform

In order to accomplish the main objective, it will be necessary to learn how to use the Arduino Development Platform. As such, I will need to learn the language and how to best make use of the hardware available to me.

### Setting up the controllers

The accelerometer module and correction system (stepper motor, etc.) will need to be set-up in accordance to system design.

### Algorithm Design

Calculations for the amount of force needed to correct the system will have to be assessed.

### Algorithm Testing

The calculations from the previous sub-objective will need to be tested and adjusted to optimize performance of the system.

## Project Beneficiaries

Those who stand to benefit from this project would be contractors in charge of systems that have a mission-critical need for physical stability. As the proposed system would be capable of managing the alignment of a system, it is feasible that it could be extended or scaled to better accommodate larger or smaller systems.

## Work Plan

The work plan I propose is that of a Waterfall model of development, sub-categorized into 4 main phases: Design, Build, Testing, and Review. Each period will take approximately 14-16 days to fully complete[[2]](#footnote-2). This workflow will account for enough time for things to overlap, so that in the event that certain tasks from the previous phase remain uncompleted can be finished or future tasks can be started-on ahead of schedule.

### Design Phase

This period is allocated to the planning and design of the proposal system. During this period, schematics for the physical design and a general calculations for the correction algorithm will be drafted in preparation for the next phase.

### Build Phase

This period is allocated to the implementation of the schematic as proposed in 1.4.1 – the system will be assembled, and the codebase put together. Different iterations of the proposed system will be made and some testing will occur during this 2 week period.

### Testing Phase

Majority of testing will occur during this phase. Results will be documented, and adjustments made to bring the system more into line to the design specification.

### Review Phase

Last adjustments to the system will be implemented during this period. Documentation will be collated and any remaining flaws in the system (bugs in code, system errors) will be addressed during this phase.

## Project Risks

As with any plan, certain risks are involved with this project. Objectively, there are two major risk factors associated with this project; Corruption, and System (Hardware) Failure. Both risk factors are elaborated upon below as well as their proposed solutions.

### Corruption

As the timeline for the project is somewhat extended (~60 days of work according to the How-to document), the possibility of data loss becomes apparent. This risk factor will be mitigated by the implementation of automated versioning (via Arduino platform) and file redundancy (via Windows OneDrive, Google Drive).

### System Failure

As the project design has physical, interacting components, there exists a possibility that damage will occur to the system in the form of Hardware wear and tear. In this case, the proposed solution will be to have multiple replacement components of equal specification on-hand to substitute.

## Research Material

Key References

### *BigDog* project paper from Boston Dynamics:

<http://www.bostondynamics.com/img/BigDog_IFAC_Apr-8-2008.pdf>

Raibert, Marc, et al. "Bigdog, the rough-terrain quadruped robot." *Proceedings of the 17th World Congress*. Vol. 17. No. 1. 2008.

### *Arduino for Robotics* by John-David Warren:

Warren, John-David, Josh Adams, and Harald Molle. *Arduino for Robotics*. Apress, 2011.

## Ethics Form

|  |  |  |
| --- | --- | --- |
| **A.1 If your answer to any of the following questions (1 – 3) is YES, you must apply to an appropriate external ethics committee for approval.** | | *Delete as appropriate* |
| 1. | Does your project require approval from the National Research Ethics Service (NRES)? For example, because you are recruiting current NHS patients or staff? If you are unsure, please check at http://www.hra.nhs.uk/research-community/before-you-apply/determine-which-review-body-approvals-are-required/. | **No** |
| 2. | Does your project involve participants who are covered by the Mental Capacity Act? If so, you will need approval from an external ethics committee such as NRES or the Social Care Research Ethics Committee http://www.scie.org.uk/research/ethics-committee/. | **No** |
| 3. | Does your project involve participants who are currently under the auspices of the Criminal Justice System? For example, but not limited to, people on remand, prisoners and those on probation? If so, you will need approval from the ethics approval system of the National Offender Management Service. | **No** |

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| --- | --- | --- |
| **A.2 If your answer to any of the following questions (4 – 11) is YES, you must apply to the City University Senate Research Ethics Committee (SREC) for approval (unless you are applying to an external ethics committee).** | | *Delete as appropriate* |
| 4. | Does your project involve participants who are unable to give informed consent? For example, but not limited to, people who may have a degree of learning disability or mental health problem, that means they are unable to make an informed decision on their own behalf? | **No** |
| 5. | Is there a risk that your project might lead to disclosures from participants concerning their involvement in illegal activities? | **No** |
| 6. | Is there a risk that obscene and or illegal material may need to be accessed for your project (including online content and other material)? | **No** |
| 7. | Does your project involve participants disclosing information about sensitive subjects? For example, but not limited to, health status, sexual behaviour, political behaviour, domestic violence. | **No** |
| 8. | Does your project involve you travelling to another country outside of the UK, where the Foreign & Commonwealth Office has issued a travel warning? (See <http://www.fco.gov.uk/en/>) | **No** |
| 9. | Does your project involve physically invasive or intrusive procedures? For example, these may include, but are not limited to, electrical stimulation, heat, cold or bruising. | **No** |
| 10. | Does your project involve animals? | **No** |
| 11. | Does your project involve the administration of drugs, placebos or other substances to study participants? | **No** |

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| **A.3 If your answer to any of the following questions (12 – 18) is YES, you must submit a full application to the Computer Science Research Ethics Committee (CSREC) for approval (unless you are applying to an external ethics committee or the Senate Research Ethics Committee). Your application may be referred to the Senate Research Ethics Committee.** | | *Delete as appropriate* |
| 12. | Does your project involve participants who are under the age of 18? | **No** |
| 13. | Does your project involve adults who are vulnerable because of their social, psychological or medical circumstances (vulnerable adults)? This includes adults with cognitive and / or learning disabilities, adults with physical disabilities and older people. | **No** |
| 14. | Does your project involve participants who are recruited because they are staff or students of City University London? For example, students studying on a specific course or module. (If yes, approval is also required from the Head of Department or Programme Director.) | **No** |
| 15. | Does your project involve intentional deception of participants? | **No** |
| 16. | Does your project involve participants taking part without their informed consent? | **No** |
| 17. | Does your project pose a risk to participants or other individuals greater than that in normal working life? | **No** |
| 18. | Does your project pose a risk to you, the researcher, greater than that in normal working life? | **No** |

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| --- | --- | --- |
| **A.4 If your answer to the following question (19) is YES and your answer to all questions 1 – 18 is NO, you must complete part B of this form.** | |  |
| 19. | Does your project involve human participants or their identifiable personal data? For example, as interviewees, respondents to a survey or participants in testing. | **No** |

## Appendix

### Proposed Timetable Gantt Chart

1. Raibert, Marc, et al. "Bigdog, the rough-terrain quadruped robot." Proceedings of the 17th World Congress. Vol. 17. No. 1. 2008. [↑](#footnote-ref-1)
2. *Appendix: [1.8.1]* [↑](#footnote-ref-2)