**MSc Dissertation**

**Motion Signal Extraction Framework for the Microsoft Kinect Camera: Point Cloud Registration and its Application as a Motion Correction Metric in PET/CT**

Submitted for the MSc in

Advanced Computer Science

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By

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# Introduction

This is a report that describes the initial research and design stages of the project to develop a motion signal extraction framework for the Microsoft Kinect camera and to then apply the output of this framework to the task of motion correction in positron emission tomography (PET) scanners.

This report includes sections detailing:

1. An introduction to the project
2. Background research which has been conducted.

PET is a common medical imaging modality used for acquiring functional images. These scans can take upwards of a few minutes to complete and during this time a subject could move for any number of reasons, including breathing (respiratory motion). Current practise is to ignore this movement, however, any movement no matter how slight degrades image resolution and introduces motion related artefacts.

Currently a stand-alone, cross-platform framework is under development to provide a facility for image analysis, reconstruction and data processing of a multitude of data formats acquired through the use of PET, SPECT, CT and MRI scanners. The goal of this project will be the development of modules or libraries that are able to extract motion vector fields or translations using the Microsoft Kinect camera. These modules or libraries should be able to be integrated into the framework mentioned previously, to aid in motion compensated reconstruction on the Sedecal Argus Scanner.

This application will acquire data from a 3D stereo camera creating point cloud representations of a scene and will then calculate and output a vector field or translation that represents the changes in position of these points over time. These vector fields or translations can then be used in motion correction or motion compensated medical imaging reconstruction to aid in the elimination of motion related artefacts.

This development of this project will take place using STIR, image reconstruction toolkit version 3 and will be compatible with an open source, cross-platform application developed by the PET preclinical centre at the University of Hull.

# Background

# Specification

1. Research Proposal

A stand-alone cross-platform framework for image analysis, reconstruction and data processing of a variate of data acquired by PET/SPECT scanners and potentially MRI is under development. The framework links and makes use of external open source libraries in order to handle data formats and perform various complex tasks. The GUI is developed on QT and there is a strong drive to have cross-platform compatibility (especially between Windows and Linux).

The goal will be to provide a responsive/neat/intuitive plug-in able to acquire data from a Microsoft Kinect camera in an easy plug and play fashion and extract from those warp spaces and/or motion signals for motion corrected or compensated medical image reconstruction.

This is a project on scientific programming but many programming challenges have to be addressed. The successful candidate will need to fluent in a C variance, with drive to improve his skills on C++ and CMake.

1. Task List

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Task Name** | **Description** | **Duration**  **(weeks)** |
| 1 | Research | Conduct background research that will aid in the writing of the initial report and the design of the application | 3 |
| 2 | Initial report | Write the initial report | 1 |
| 3 | Create standalone console application to interface with Kinect |  | 1 |
| 4 | Add ability to save point cloud from Kinect to file or data type |  | 1 |
| 5 | Add ability to output multiple point clouds per execution |  | 1 |
| 6 | Add ability to timestamp output |  | 1 |
| 7 | Add ability to clean point clouds |  | 2 |
| 8 | Add ability to register between point clouds |  | 3 |
| 9 | Add ability to extract vector field or translation from registered point clouds |  | 3 |
| 10 | Add ability to remove extraneous data from point cloud |  | 3 |
| 11 | Add ability to synchronise timestamp on point cloud to output from scanner |  | 3 |
| 12 | Add ability to translate camera space to scanner space |  | 3 |
| 13 | Add ability to apply output from application to output from scanner |  | 3 |
| 14 | Final report | Write the final report | 5 |
| 15 | Port application to Linux |  | 2 |
| 16 | Add application to STIR as library |  | 2 |

1. Time Plan

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **#** | **Task Name** | **Weeks** | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | Research |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | Initial report |  |  |  | D |  |  |  |  |  |  |  |  |
| 3 | Create server client |  |  |  |  |  |  |  |  |  |  |  |  |
| 4 | Create TCP server |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 | Add UDP to server |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 | Add multithreading capabilities to server |  |  |  |  |  |  |  |  |  |  |  |  |
| 7 | Create main menu for game |  |  |  |  |  |  |  |  |  |  |  |  |
| 8 | Add game screen and assets to game |  |  |  |  |  |  |  |  |  |  |  |  |
| 9 | Add map to game screen |  |  |  |  |  |  |  |  |  |  |  |  |
| 10 | Add translations and scaling to map |  |  |  |  |  |  |  |  |  |  |  |  |
| 11 | Add player character and movements to map |  |  |  |  |  |  |  |  |  |  |  |  |
| 12 | Interim report |  |  |  |  |  |  |  |  |  |  |  |  |
| 13 | Add client calls to store and recall player positions from server |  |  |  |  |  |  |  |  |  |  |  |  |
| 14 | Final report |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 | Add tracking data and bounds of playing field to game |  |  |  |  |  |  |  |  |  |  |  |  |
| 16 | Add taking mechanics from tracking data to game |  |  |  |  |  |  |  |  |  |  |  |  |
| 17 | Add killing mechanics from tracking data to game |  |  |  |  |  |  |  |  |  |  |  |  |
| 18 | Add scoring data to game |  |  |  |  |  |  |  |  |  |  |  |  |
| 19 | Add team mode to game |  |  |  |  |  |  |  |  |  |  |  |  |
| 20 | Add multigame server |  |  |  |  |  |  |  |  |  |  |  |  |

1. Risk Assessment

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk** | **Current Risk** | | | **How to Avoid** | **How to Recover** | **Residual Risk** | | |
| **Severity**  **(L/M/H)** | **Likelihood**  **(L/M/H)** | **Significance (Severity, Likelihood)** | **Severity**  **(L/M/H)** | **Likelihood**  **(L/M/H)** | **Significance (Severity, Likelihood)** |
| Data loss | H | M | HM | Keep backups | Reinstate from backups | L | M | LM |
| Loss of backups | H | L | HL | Keep multiple backups on multiple different forms of media in multiple different locations | Use alternate backup | L | L | LL |
| Underestimate workload | H | M | HM | Regularly review progress against Time Plan | Invest more time into work or reduce objectives | H | L | HL |
| Critical error in deliverable | H | M | HM | Perform adequate background research | Thoroughly test and debug code | H | L | HL |
| Skill Risk | M | M | MM | Perform adequate training or seek out specialists | Invest more time into background research | L | L | LL |
| Scope Creep | M | H | MH | Fully define objectives | Fully define current objectives and do not change the objectives again | M | L | ML |
| Inefficient Program Performance | H | L | HL | Invest time in testing and debugging code | Optimise code or remove slow code | M | L | ML |
| Medical emergency | H | L | HL | Care for developers health including regular periods of rest | Comment code regularly so that it is well understood | M | L | ML |

1. Ethics Report

If your project uses other people (‘participants’) for the collection of information (typically in getting comments about a system or a system design, getting information about how a system could be used, or evaluating a working system) then you need to read through the checklist in Section A below before completing the declaration in Section B.

If your project does **not** make use of other people then you can skip Section A and directly complete the declaration in Section B by marking box ‘1’ with an X.

Section A

**1. Participants will not be exposed to any risks greater than those encountered in their normal working life.**

Researchers have a responsibility to protect participants from physical and mental harm during the investigation. The risk of harm must be no greater than in ordinary life. Areas of potential risk that require ethical approval include, but are not limited to, investigations that occur outside usual laboratory areas, or that require participant mobility (e.g. walking, running, use of public transport), unusual or repetitive activity or movement, that use sensory deprivation (e.g. ear plugs or blindfolds), bright or flashing lights, loud or disorienting noises, smell, taste, vibration, or force feedback

**2. The experimental materials will be paper-based, or comprised software running on standard hardware.**

*Participants should not be exposed to any risks associated with the use of non-standard equipment: anything other than pen-and-paper, standard PCs, mobile phones, and PDAs is considered non-standard.*

**3. All participants will explicitly state that they agree to take part, and that their data could be used in the project.**

*If the results of the evaluation are likely to be used beyond the term of the project (for example, the software is to be deployed, or the data is to be published), then signed consent is necessary. A separate consent form should be signed by each participant.*

*Otherwise, verbal consent is sufficient, and should be explicitly requested in the introductory script.*

**4. No incentives will be offered to the participants.**

*The payment of participants must not be used to induce them to risk harm beyond that which they risk without payment in their normal lifestyle.*

**5. No information about the evaluation or materials will intentionally be withheld from the participants.**

*Withholding information or misleading participants is unacceptable if participants are likely to object or show unease when debriefed.*

**6. No participant will be under the age of 16.**

*Parental consent is required for participants under the age of 16.*

**7. No participant will have an impairment that may limit their understanding or communication.**

*Additional consent is required for participants with impairments.*

**8. Neither I nor my supervisor is in a position of authority or influence over any of the participants.**

*A position of authority or influence over any participant must not be allowed to pressurise participants to take part in, or remain in, any experiment.*

**9. All participants will be informed that they can withdraw at any time.**

*All participants have the right to withdraw at any time during the investigation. They should be told this in the introductory script.*

**10. All participants will be informed of my contact details.**

*All participants must be able to contact the investigator after the investigation. They should be given the details of both student and module coordinator or supervisor as part of the debriefing.*

**11. The evaluation will be discussed with all the participants at the end of the session, and all participants will have the opportunity to ask questions.**

*The student must provide the participants with sufficient information in the debriefing to enable them to understand the nature of the investigation.*

**12. All the data collected from the participants will be stored in an anonymous form.**

*All participant data (hard-copy and soft-copy) should be stored securely, and in anonymous form.*

If your evaluation does comply with all the twelve points above, please mark box ‘2’ in Section B.

If your evaluation does not comply with one or more of the twelve points above, please mark box ‘3’ in Section B unless you **know** that your supervisor already has ethical approval for the project (in which case mark box ‘4’). If you are unsure mark box ‘3’.

*[adapted from Department of Computing Science University of Glasgow Ethics checklist form for 3rd/4th/5th year, MSc IT/CS/ACS projects 2007]*

Section B

|  |  |
| --- | --- |
| Student Name | Alexander C Whitehead |
| Project Title | Motion Signal Extraction Framework for the Microsoft Kinect Camera: Point Cloud Registration and its Application as a Motion Correction Metric in PET/CT |
| Supervisors Names | Dr D Parker  Dr N Efthymiou |

|  |  |  |
| --- | --- | --- |
| This is a declaration that the ethical concerns for above project have been considered (in particular with regards to the 12 point checklist above) with the following outcome: | | Please mark only ONE box with an X |
| 1 | This project does not involve other people in the collection of information and therefore does not require an ethical review | X |
| 2 | This project complies with the **entire** twelve point ethical checklist and therefore does not require ethical review. |  |
| 3 | This project does not comply with **all** of the twelve points above and therefore does require ethical review and the completion and submission of an ethical approval form. |  |
| 4 | This project does not comply with **all** of the twelve points above, however the supervisor already has ethical approval for this research |  |

If you have marked box ‘3’ you will be expected to apply for ethical approval. Further advice is available from both your project supervisor and the Department’s Ethical Officer, as well as by reading and completing [this form](https://canvas.hull.ac.uk/files/317681/download?download_frd=1).

References

Miranda, A., Staelens, S., Stroobants, S. & Verhaeghe, J., 2017. Markerless rat head motion tracking using structured light for brain PET imaging of unrestrained awake small animals. *Physics in Medicine & Biology,* 62(5).