Virtual Tailor

Human Body Parameter Determination using a Kinect Sensor

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Declaration

1. I know that plagiarism is wrong. Plagiarism is to use another's work and pretend that it is one's own.
2. I have used the IEEE convention for citation and referencing. Each contribution to, and quotation in, this report from the work(s) of other people has been attributed, and has been cited and referenced.
3. This report is my own work.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as their own work or part thereof.

Signature:.....
Nevarr Pillay

Date:.....

Acknowledgments

Abstract

- Open the **Project Report Template.tex** file and carefully follow the comments (starting with %).
- Process the file with **pdflatex**, using other processors may need you to change some features such as graphics types.
- Note the files included in the **Project Report Template.tex** (with the .tex extension excluded). You can open these files separately and modify their contents or create new ones.
- Contact the latex namual for more features in your document such as equations, subfigures, footnotes, subscripts & superscripts, special characters etc.
- I recommend using the **kile** latex IDE, as it is simple to use.

Contents

Chapter 1

Introduction

1.1 Background to the study

A very brief background to your area of research. Start off with a general introduction to the area and then narrow it down to your focus area. Used to set the scene [1].

1.2 Objectives of this study

1.2.1 Problems to be investigated

Description of the main questions to be investigated in this study.

1.2.2 Purpose of the study

Give the significance of investigating these problems. It must be obvious why you are doing this study and why it is relevant.

1.3 Scope and Limitations

Scope indicates to the reader what has and has not been included in the study. Limitations tell the reader what factors influenced the study such as sample size, time etc. It is not a section for excuses as to why your project may or may not have worked.

1.4 Plan of development

Here you tell the reader how your report has been organised and what is included in each chapter.

I recommend that you write this section last. You can then tailor it to your report.

Chapter 2

Literature Review

Technology background

1. Depth Sensor technology + How Kinect works
2. Point cloud map

Coding references/Getting started

3. Code references and and blog posts?
4. Previous example
5. Hand Example

Mathematics Used

6. Papers on ellipse circumference

Improving Accuracy

7. Skeleton Joints filtering
8. Error Model

Further developments

9. Augmented reality paper

Imaging Processing Background

10. Basics of an image - RGB
11. Matlab

12. Camera Model

Uncertainty Measurements

13. Gaussian

14. Triangular

Once upon a time engineers and researchers believed... In this area of research, they used the following methods... [2]

Write this section first as it will take you the longest. I suggest you start writing this as soon as you have done your initial research at the beginning of your project. You can then return to it once you have completed your work to edit and adjust it.

A literature review forms the theoretical basis of your project. You need to read a large number of journal papers, sections in books, technical reports etc. relevant to your work at the start of project. This will give you a good idea of the field of research.

When writing your review start of with the general concepts and move to the more specific aspects explaining the necessary theory as you go. This section is NOT a copy and paste from others work or a rewrite-but-change-one-word section. I suggest you read all your material, and then put it down and write this section, referring back to the work only when you need to check something.

See your PCS textbook for more details on how to write a literature review.

If you include a figure or a table in your text please see the example in Fig. 2.1 as to how to caption it. Please make sure that all text in your figures is readable and that you reference your figures if they are from another source.

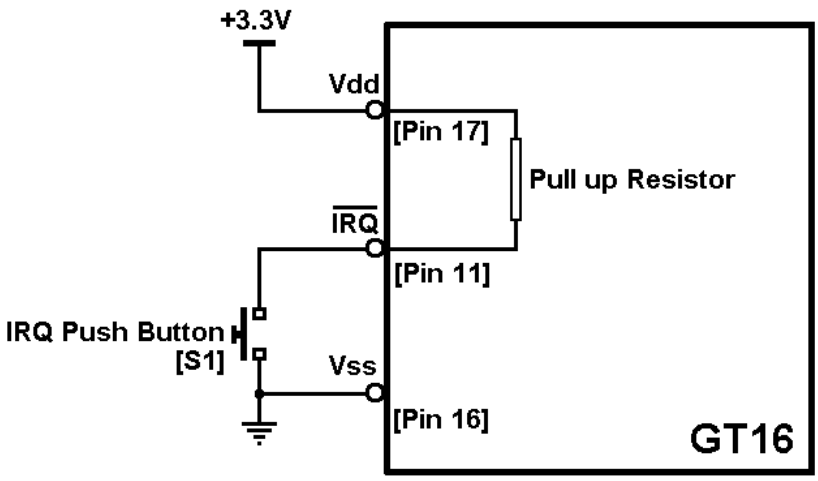

Figure 2.1: A block diagram illustrating the connections to the IRQ pin on the MCS08GT16A microcontroller (Please note that your headings should be short descriptions of what is in the diagram not simply the figure title)

Chapter 3

Background Information

Skeleton tracking
Known errors
Guidelines for measurements

Chapter 4

Solution Design

4.1 Implementation Design

1) Online profile of people - Used for online shopping and retail shops
2) Take measurements at a retailer - Virtual Dressing room - A part of the shopping experience and will reduce hassle of trying on clothes
3) Amount wasted in trying on clothes or online returns?
4) Could be used for personalised tailoring 5) Example of UI - Explanation of how it works

4.2 Component Selection

1) Choice of Kinect
2) Choice of Windows SDK

4.3 Algorithm Design

1) Windows examples used - Background Removal, Colour Stream and Skeleton Tracking

2) Run through of algorithm - Background Removed frame - Send image to separate

class for processing - Create array with background removed pixels - Draw skeleton on image - Create axes for measurement - Perpendicular or straight depending on particular measurement

4.4 Experimental Design

- Constraints - Men, distance from Kinect, Number of views, 3D Modelling - UI to run simulated dressing room - Volunteer to pose as instructed by person controlling UI - Take measurement of front - Take left - Take back - Take right - At each point, take actual readings with uncertainty - For one volunteer, take 5 readings in relatively the same pose - Determine uncertainty

Chapter 5

Methodology

This is what I did to test and confirm my hypothesis.

You may want to split this chapter into sub chapters depending on your design. I suggest you change the title to something more specific to your project.

This is where you describe your design process in detail, from component/device selection to actual design implementation, to how you tested your system. Remember detail is important in technical writing. Do not just write I used a computer give the computer specifications or the oscilloscopes part number. Describe the system in enough detail so that someone else can replicate your design as well as your testing methodology.

If you use or design code for your system, represent it as flow diagrams in text.

1. This is a bullet point test
2. I hope this works

5.1 Aim

The aim of this project was to create a system that enabled the measurement of different parts of a human body

Chapter 6

Results

These are the results obtained from the investigation outlined in 5. Seven volunteers were used in determining the accuracy of the system. They were first measured by the system and then their physical measurements were obtained for comparison. (For further details, see section 5)

This section begins with a presentation of the overall results of the system and a comparison with the aim of the investigation. Subsequent sections present further analyses of the performance of specific areas of the system. These sections detail more extensive insights discovered throughout the investigation and focus on the following areas major of the system:

- The accuracy of each view of measurement (Front, Left, Back and Right).
- The accuracy of measuring each individual limb.
- The impact that clothing worn by a person being measured has on the system's accuracy.
- Other empirical insights obtained through use and observation of the system.

6.1 Overall Results

Below is a summary of the aggregate accuracy of the system and the accuracy per volunteer, together with their personal characteristics. (Table 6.1)

Table 6.1: Overall results of accuracy of system per volunteer

Volunteer Number	***Average Error***	***Build***	***Height***	***Clothing***
1	28.44%	Athletic	Tall	Tight
2	17.27%	Athletic	Average	Tight
3	16.45%	Athletic	Tall	Vest
4	40.75%	Slim	Average	Loose
5	20.72%	Big	Average	Loose
6	19.60%	Slim	Short	Tight
7	18.83%	Big	Average	Vest
Total Average Error		23.15%		

As seen in Table 6.1, despite the average error of individual volunteers being outside the desired range of 25% accuracy, the total average error of the system is 23.15%. Therefore, the system performed such that it met the requirements of achieving an accuracy better than 25%, as stipulated in section 5.1.

The observed factors that had the greatest contribution to inaccuracy are listed below in order of impact:

1. The system not being able to accurately determine the extremities of the body.
2. The inconsistency of the plane being used to take the measurement.
3. The error or "jitter" of the tracked skeleton.

6.2 View Performance

Each "view" (Front, Left, Back or Right) of the system has a unique set of characteristics. It is useful to investigate the performance of each of them to better understand their effectiveness in the system as a whole.

Seen below in Table 6.2 are the results of the average accuracy of each view obtained after measuring the volunteers in each of the respective views.

Table 6.2: Results of the average accuracy of each view per volunteer

Volunteer Number	***Front***	***Left***	***Back***	***Right***
1	21.82%	29.90%	32.61%	31.04%
2	16.58%	15.81%	20.45%	14.60%
3	17.27%	19.01%	15.53%	13.37%
4	35.58%	58.15%	33.58%	44.77%
5	21.06%	10.39%	24.92%	23.47%
6	11.65%	44.58%	14.09%	17.07%
7	20.72%	19.51%	20.60%	12.06%
Total Avg Error	***20.67%***	***28.19%***	***23.11%***	***22.34%***

The results obtained in Table 6.2, together with the detailed results of each volunteer available in Appendix A have yielded insights for each of the views. They are discussed in the subsequent subsections.

6.2.1 Front Performance

The "Front" view performed the best overall with an average accuracy of 20.67%. This can be attributed to the fact that the Kinect performs the best when a person faces it head on (Parallel to the image plane). This is due to the Kinect being able to fully track the skeleton of the user. As a result, a more accurate and reliable skeletal coordinate system can be used, which in turn provide more accurate planes of measure.

All joints and skeleton tracked

6.2.2 Left Performance

6.2.3 Back Performance

6.2.4 Right Performance

Front was the most accurate

6.3 Limb Performance

Table 6.3: Results of the average accuracy of Upper Body Limbs

Volunteer Number	***Chest***	***Upper Left Arm***	***Lower Left Arm***	***Upper Right Arm***	***Lower Right Arm***
1	49.50%	29.90%	10.10%	26.35%	11.02%
2	27.84%	23.16%	9.84%	17.74%	13.24%
3	14.58%	10.99%	24.14%	7.33%	12.27%
4	79.55%	12.20%	26.74%	33.79%	5.47%
5	45.85%	21.22%	8.41%	15.16%	14.82%
6	23.39%	6.64%	15.91%	8.46%	8.63%
7	30.70%	12.34%	12.71%	12.02%	7.95%
Total Avg Error	***38.77%***	***16.64%***	***15.41%***	***17.26%***	***10.48%***

6.4 Impact of Clothing

6.5 Other Empirical Insights

1) Overall results - Include overall average and data set

Table 6.4: Results of the average accuracy of Lower Body Limbs

Volunteer Number	***Waist***	***Upper Left Leg***	***Lower Left Leg***	***Upper Right Leg***	***Lower Right Leg***
1	32.09%	31.47%	13.58%	28.07%	44.04%
2	25.36%	15.32%	14.18%	13.21%	6.61%
3	20.51%	13.09%	24.62%	20.01%	10.12%
4	80.55%	13.36%	27.94%	25.40%	48.15%
5	26.74%	16.08%	8.56%	24.17%	15.81%
6	35.04%	20.78%	43.78%	9.58%	17.38%
7	19.53%	23.78%	22.77%	26.17%	16.17%
Total Avg Error	***34.26%***	***19.13%***	***22.20%***	***20.95%***	***22.61%***

Table 6.5: Overall results of accuracy of system per volunteer after adjustments for clothing

Volunteer Number	***Average Error***	***Build***	***Height***	***Clothing***
2	17.27%	Athletic	Average	Tight
3	16.45%	Athletic	Tall	Vest
6	19.60%	Slim	Short	Tight
7	18.83%	Big	Average	Vest
Total Error Average		***18.04%***		

Table 6.6: Results of the average accuracy of each view per volunteer after adjustments for clothing

Volunteer Number	***Front***	***Left***	***Back***	***Right***
2	16.58%	15.81%	20.45%	14.60%
3	17.27%	19.01%	15.53%	13.37%
6	11.65%	44.58%	14.09%	17.07%
7	20.72%	19.51%	20.60%	12.06%
Total Avg Error	***16.55%***	***24.73%***	***17.67%***	***14.27%***

Table 6.7: Results of the average accuracy of Upper Body Limbs after adjustments for clothing

Volunteer Number	***Chest***	***Upper Left Arm***	***Lower Left Arm***	***Upper Right Arm***	***Lower Right Arm***
2	27.84%	23.16%	9.84%	17.74%	13.24%
3	14.58%	10.99%	24.14%	7.33%	12.27%
6	23.39%	6.64%	15.91%	8.46%	8.63%
7	30.70%	12.34%	12.71%	12.02%	7.95%
Total Avg Error	***24.13%***	***13.28%***	***15.65%***	***11.39%***	***10.52%***

Table 6.8: Results of the average accuracy of Lower Body Limbs after adjustments for clothing

Volunteer Number	***Waist***	***Upper Left Leg***	***Lower Left Leg***	***Upper Right Leg***	***Lower Right Leg***
2	25.36%	15.32%	14.18%	13.21%	6.61%
3	20.51%	13.09%	24.62%	20.01%	10.12%
6	35.04%	20.78%	43.78%	9.58%	17.38%
7	19.53%	23.78%	22.77%	26.17%	16.17%
Total Avg Error	***25.11%***	***18.24%***	***26.34%***	***17.24%***	***12.57%***

2) Results per view

2) Results per limb

4) Impact of clothing

8) Empirical Insights - Trying to determine a correct measurement, Legs not together, length of people, skinny person, skeleton not perfectly fitting

5) Uncertainty model

6) Circumference results - Ellipse 7) Circumference results - Rectangle

9) Improved UI 10) Data Set Analysis

Test of Table 6.9 added to results

Table 6.9: Add caption

	Chest	Waist	Upper Left Arm	Lower Left Arm	Upper Right Arm	Lower Right Arm	Upper Left Leg	Lower Left Leg	Upper Right Leg	Lower Right Leg
Front	38.92	38.27	7.97	9.28	7.09	7.27	24.72	12.55	24.38	12.02
Front	38	31	11.5	9	12	7.5	15.5	10.5	15.5	10.5
Error	2.42%	23.45%	-30.70%	3.11%	-40.92%	-3.07%	59.48%	19.52%	57.29%	14.48%
Left	28.73	31.96	7.39	8.73	#N/A	#N/A	20.05	12.55	#N/A	#N/A
Left	20	20.5	11	7.5	#N/A	#N/A	14.5	11.5	#N/A	#N/A
Error	43.65%	55.90%	-32.82%	16.40%	#N/A	#N/A	38.28%	9.13%	#N/A	#N/A
Back	80.37	34.58	8.12	8.31	7.88	7.37	22.38	12.89	23.54	11.05
Back	35	30	11	7.5	11.5	9.5	15	11.5	14.5	11.5
Error	129.63%	15.27%	-26.18%	10.80%	-31.48%	-22.42%	49.20%	12.09%	62.34%	-3.91%
Right	25.68	29.42	#N/A	#N/A	9.8	8.78	#N/A	#N/A	17.38	24.58
Right	21	22	#N/A	#N/A	10.5	9.5	#N/A	#N/A	17	11.5
Error	22.29%	33.73%	#N/A	#N/A	-6.67%	-7.58%	#N/A	#N/A	2.24%	113.74%

Chapter 7

Discussion

Here is what the results mean and how they tie to existing literature...

Discuss the relevance of your results and how they fit into the theoretical work you described in your literature review.

Chapter 8

Conclusions

These are the conclusions from the investivation and how the investigation changes things in this field or contributes to current knowledge...

Draw suitable and intelligent conclusions from your results and subsequent discussion.

Chapter 9

Recommendations

1) Statistical Model in taking readings
2) Automatic system to remove the need for a person 3) Clothing model 4) AI for understanding body shape 5) Better modelling of 3D body parts 6) Extension to cellphone 7) Full 3D parameter modelling - Body parts, skin contours, body fat% etc. 8) Filtering skeleton joints

Use the IEEE numbered reference style for referencing your work as shown in your thesis guidelines. Please remember that the majority of your referenced work should be from journal articles, technical reports and books not online sources such as Wikipedia.

Bibliography

[1] M. S. Tsoeu and M. Braae, "Control Systems," *IEEE*, **vol. 34(3)**, pp. 123-129, 2011.

[2] J. C. Tapson, *Instrumentation*, UCT Press, Cape Town, 2010.

Appendix A

Detailed Results of Volunteers

Add any information here that you would like to have in your project but is not necessary in the main text. Remember to refer to it in the main text. Separate your appendices based on what they are for example. Equation derivations in Appendix A and code in Appendix B etc.

Appendix B

Addenda

B.1 Ethics Forms