ASTRO3DO

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MASTER OF SCIENCE

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To those in need,

Those with or destined for cancer,

and the group.

ACKNOWLEDGMENTS

I want to thank god for this.

ABSTRACT

There are several key components of health, which can be monitored through means of body composition and shape analysis. Metrics such as fat mass index and fat free mass index are simple features of the humany body that can aid our understanding in their overall health. How these are measured have been extensively studied throughout the years. Means such as DXA and bioimpedance can accurately measure body fat. While more recently, 3d imaging has proven to be able to match the performance of its predecessors whilst providing certain benefits such as lower cost. The Shepherd Lab has demonstrated such findings by showing similar results between DXA and 3d imaging. The project is ongoing and this thesisis is the culmination of about 6 months relating to 3d imaging methods and testing for applications in space. It provides an overview of my work and the starting point of much future effort.

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CHAPTER 1
INTRODUCTION

Every dissertation should have an introduction. You might not realize it, but the introduction should introduce the concepts, background, and goals of the dissertation.

Examples of great literature can be found in table 1.1.

Table 1.1: A normal size table. There has been a complaint that table captions are not single-spaced, but they should be. This is a test of that feature.

Title	Author
War And Peace	Leo Tolstoy
The Great Gatsby	F. Scott Fitzgerald

CHAPTER 2
PREVIOUS WORK

Some other research was once performed. You can check out a beautiful picture in figure 2.1.

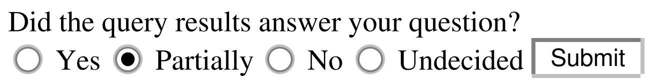

Figure 2.1: An example of included Encapsulated PostScript (EPS).

2.1 URLs

In this modern age, you may find that you wish to include URLs or pathnames which both tend to be long and hard for TeX to deal with because it doesn't know where to insert linebreaks. The "`url`" package (loaded in the main uhtest.tex file) allows one to deal with these URLs. For example:

Here is an URL which cannot be broken, leading to terrible output <http://www.hotwired.com/webmonkey/98/

Using the package we get the much nicer `<http://www.hotwired.com/webmonkey/98/16/index2a.html>` which LaTeX can handle just fine. Even better, the parameter to \`url` can have spaces inserted anywhere so you can make the LaTeX source lines in your text editor wrap nicely.

A few notes. It is recommended that you enclose your URLs in "<>" to ensure that any punctuation around the URL won't be confused as part of the URL. You can use URLs in your bibliography too (see the `uhtest.bib` file for an example). Finally, if you need to use a tilde in your URL then things are a little trickier. One way to do it is like this: `<http://www.dartmouth.edu/`$\sim$`jonh/ff-cache/1.html>`. The \`url` style uses math mode internally, so we break the URL into two pieces, and stick a tilde from math mode inbetween the two parts.

2.2 Bibliography Citations

Citing references to your bibliography is easy [?] [?]. First you build a BibTeX file which contains the records for all of the works you wish to cite. This file ends with a "`.bib`" extension. Then in your body you use the "\`cite`" command with the label you gave to the record in question. The final steps are: run LaTeX once, run BibTeX, and then run LaTeX twice more. You should now have a bibliography that includes those citations.

CHAPTER 3
METHODS

There were several things I worked on. The first is a review of different sensor technologies and subsubsequent testing of the top ones. Next was the development for the Zero G Parabolic Flight which are scheduled for the summer. Third was simulating microgravity and testing them. Fourth was seeing the impact of pose on the resulting steps and final measurements.

I did a review of the sensor technologies out there excluding the commercial systems mentioned in previous works. I looked up their specs such as resolution, depth accuracy, and frame rate. I then benchmarked them on depth accuracy, temporal noise, spatial noise, and fill rate. These benchmarks were also done at varying distances. To do so, I made a simple setup. I used an imaging chart and a laser measure. I used 10 frames for each test. The setup is shown here

Machine Learning and Deep Learning work very well in many domains.

One such deep learning method that is used for 3d data inputs are graph neural networks. The one I used specifically is called dynamic graph convolutional neural network (dgcnn). It consists of n vertices, each of which are tuple of 3 numbers. In order to apply the convolution operator, one must define an edge. With 2d images, an edge is any pixel that is adjacent to another pixel within the kernel length. For a graph, different distance metrics can be used. Dgcnn uses pairwise euclidean distances. The k nearest points are used for the subsequent convolution. Next comes the convolution kernel, which the authors define as

$$E_i j = ReLU(\theta_i * (x_j - x_i) + \theta_j * x_i) \tag{3.1}$$

Then comes max pooling for all such node j in the neighboring set of node i:

$$F_i j = Max(E_{ij}) \tag{3.2}$$

Before the point cloud goes into this architecture, they apply a matrix transformation using the coordinates and the differences with their neighbors. They prove certain desirable properties such as permutation invariance and translation invariance. And achieve state of the art results on classification and segmentation in June 2019. While they used their architecture for classification and segmentation, I convert it into regression for use in an automated caesar point placement. In Caesar, 75 landmarks are manually picked which allows a standardized template of 60k nodes to fit to the original mesh that has several hundred thousand points. Usually this takes several minutes for an expert user and can take up to an hour for a beginner. A landmark is defined as an (x, y, z) coordinate and there are 225 such numbers that are needed to be predicted in a regression case. The other method is segmentation, which is reduced to classification of each point. In which there will be several hundred thousand points which will each need to be classified into 75 classes.

Resulting in many predictions and some of these predictions may not even be exactly precise as the landmarks may not coincide directly with a point. It is hypothesized that training maybe easier in the beginning; however, in the long term one would expect a degradation in results because their is much noise. This noise comes from the fact that many points don't belong, and only 75 are really needed. With regression, one can predict the exact point and get to perfect performance. But the beginning of training may be more difficult as the predictions are totally random and the errors will be large.

In order to choose the best sensor one could use intermediate metrics that define how good that sensor or one could use all of those sensors in the overall imaging setup and analysis and see which one works the best. Ideally, both should be done. I started with the first. The metrics thus defined are Z-accuracy, Fill Rate, spatial noise, and temporal noise. The Z-accuracy says how accurate the depth sensor is in relation to a ground truth(GT). We average the differences in depth sensor value and ground truth. Each metric is for a given single frame and was then average across 10 frames.

$$z - accuracy = \frac{1}{n}\sum_p (Image - GT) \forall p \in box \tag{3.3}$$

The fill rate relates to how many of the depth pixels are valid. This is useful as some sensors have high accuracy but low fill rate. This is the percentage of pixels that are non-zero.

$$Fill - rate = \frac{\sum_p [I_p >= 0]}{|p|} \forall p \in box \tag{3.4}$$

Spatial noise I define as the standard deviation divided by the mean distance. The RMS error or spatial noise is useful to determine the x-y noise from a plane that is approximately equidistant from the imaging sensor.

$$noise = \sqrt{\frac{1}{n-1}\sum_p (I_p - \bar{I_p})^2 \forall p \in box} \tag{3.5}$$

Last comes the temporal noise. Which is esentially the same as spatial noise except we take it across frames of the same pixel location.

$$temporal - noise = \sum_p \sqrt{\frac{1}{n-1}\sum_{f=1}^{10} (I_{pf} - \bar{I_p})^2 \forall p \in box} \tag{3.6}$$

These 4 metrics are what I test. In addition to that, I compare things such as frame rate, field of view, weight, dimensions, resolution, sdks, minimum z distance and maximum z distance.

CHAPTER 4
RESULTS

CHAPTER 5
CONCLUSION

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5.1 Widgets

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5.1.1 Sub-Widgets

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Sub-Sub-Widgets

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APPENDIX A
SOME ANCILLARY STUFF

Ancillary material should be put in appendices, which appear before the bibliography.

APPENDIX B
MORE ANCILLARY STUFF

Subsequent chapters are labeled with letters of the alphabet.