

[Your Title Here]

by

Minwoo Kim

Department of Computer Science  
Duke University

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Mary Missy Cummings, Supervisor

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[External Committee Member]

Dissertation submitted in partial fulfillment of the requirements for the degree of  
Doctor of Philosophy in the Department of Computer Science  
in the Graduate School of Duke University  
2018

## ABSTRACT

[Your Title Here]

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# **Abstract**

Write your abstract here. You should not include references or mathematical notation.

If you want to dedicate your thesis to anyone do so here

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# List of Abbreviations and Symbols

## Symbols

Put general notes about symbol usage in text here. Notice this text is double-spaced, as required.

- $\mathbb{X}$  A blackboard bold  $X$ . Neat.
- $\mathcal{X}$  A caligraphic  $X$ . Neat.
- $\mathfrak{X}$  A fraktur  $X$ . Neat.
- $\mathbf{X}$  A boldface  $X$ .
- $\text{X}$  A sans-serif  $X$ . Bad notation.
- $X$  A roman  $X$ .

## Abbreviations

Long lines in the `symbollist` environment are single spaced, like in the other front matter tables.

AR	Aqua Regia, also known as hydrochloric acid plus a splash of nitric acid.
SHORT	Notice the change in alignment caused by the label width between this list and the one above. Also notice that this multiline description is properly spaced.
OMFGTXTMSG4ME	Abbreviations/Symbols in the item are limited to about a quarter of the textwidth, so don't pack too much in there. You'll bust the margins and it looks really bad.

# Acknowledgements

Thank anyone you like here. It's good practice to thank every granting agency that's given you money since you've been ABD, any other school you visited during your research, and any professional society that's funded your travel.

# 1

## Introduction

Type your introduction here. This is “technically” your first chapter of the dissertation/thesis.

# 2

## Duke Dissertation Class Documentation

`dukedissertation.cls` — a document class for dissertations and theses conforming to the 2011 Duke University guidelines. This class is by Michael Gratton and modified by Hugh Crumley. It is based on the 2004 L<sup>A</sup>T<sub>E</sub>X2 $\epsilon$  version of report.cls and code in the older dukethesis.cls dating back to 1987.

The report.cls is Copyright 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 The LaTeX3 Project.

The original dukethesis.cls contained work by Mark Holliday, Charlie Martin, Russ Tuck, Sean O'Connell, Michael Todd, Syam Gadde, and Rajiv Wickremesinghe. Some of this work has been folded into the new document class.

This file may be distributed and/or modified under the conditions of the LaTeX Project Public License, either version 1.3 of this license or (at your option) any later version. The latest version of this license is in <http://www.latex-project.org/lppl.txt> and version 1.3 or later is part of all distributions of LaTeX version 2003/12/01 or later.

This is the June 13, 2011 version, 0.5, (updated by Hugh Crumley) by Michael

Gratton.<sup>1</sup>

## 2.1 Features

This class conforms to the 2011 style guidelines for dissertations, including:

1. Page numbers centered in the footer of each page
2. Margins: 1in top, 1in right, 1.5in left, 1in below footer
3. Title signature page, UMI abstract title signature page, and copyright page automatically generated at \maketitle
4. 'Double' spacing throughout body text (really about 10pt extra instead of 12pt extra.)
5. Double spacing between and single spacing within the Table of Contents, List of Tables, List of Figures, Bibliography, and in chapter, section titles, and figure/table captions.
6. Footnotes are numbered consecutively within a chapter and placed at the bottom of the page on which the reference number appears.
7. Page ordering and numbering: roman numeral page numbers appear in the frontmatter (prior to the introduction or Chapter 1). The first numbered page is the Abstract (iv). Arabic numbering from '1' starts in the Introduction or Chapter 1 if there's no Introduction.
8. Optional material supported:
  - Dedication
  - Acknowledgements

---

<sup>1</sup> E-mail: mgratton@math.duke.edu

- Introduction (different from 'Chapter 1: Introduction')
- Appendices

This class also provides some handy features:

1. Use the option 'economy' to get a single-spaced document appropriate for giving to colleagues.
2. Change your copyright from 'All rights reserved' if you're not actually reserving all your rights.
3. New Look: boldface mostly removed in headers for a lighter feel. The word 'Chapter' no longer appears on opener pages, only the number.

## 2.2 Limitations

In it's current form, this class does not support committees larger than six members, or titles longer than four lines. The figure-to-caption space has been abbreviated, as most plotting programs provide ample bottom margins. This default may not be acceptable in all cases.

## 2.3 Class options

The class supports the following options. Options appear in pairs with the default option in each pair listed first. The exception is the first listed option, which merely activates several other options for convenience.

**economy** Macro. Enables the options singlespace, nogradschool, and nobind. **Changed in version 0.3**

**gradschool** Default. Produces signature lines and a UMI abstract title page.

**nogragschool** Suppresses the above.

**PhD** Default. Format is suitable for a Ph.D dissertation.

**MS** Modifies the format for Masters Theses. Changes the text on the title page, omits the UMI page, and generates warnings when forbidden document parts are used (i.e., Biography).

**openany** Default. Allows a chapter to start on any page.

**openright** Chapters only start on right-hand pages. Only makes sense for twosided documents.

**oneside** Default. Wide margin (where the binding will be) always occurs on the left edge of a page.

**twoside** Wide margin occurs on the left of odd pages and the right of even pages. This is for binding duplex printed documents.

**final** Default. No extra marks, include all pictures.

**draft** Prints black bars on pages where the contents overflow the margins. Suppresses the inclusion of graphics for speed.

**doublespace** Default. Double-spaces body text and adds extra space between entries in the Table of Contents, List of Figures, List of Tables, List of Abbreviations, and Bibliography.

**singlespace** Normal distances between baselines in all cases. Normal spacing in all list-type environments.

**newstyle** Default. Lighter look for headings.

**oldstyle** Headings in the classic L<sup>A</sup>T<sub>E</sub>Xstyle. **New in version 0.3**

**bind** Default. 1.5in margin for binding appears on spine-side of a page.

**nobind** Left and right margins are both 1.25in. **New in version 0.3**

The default options are chosen so that the document will pass the Ph.D format specifications of the graduate school.

Here are some handy examples. Format required by graduate school:

```
\documentclass{dukedissertation}
```

Easy-to-read format for printing, sending to collaborators, etc:

```
\documentclass[economy]{dukedissertation}
```

Suitable for spiral bound copies and the like

```
\documentclass[economy, twoside, bind]{dukedissertation}
```

# 3

## Basic Document Class Features

This chapter is an example of how to format normal material in the dissertation style. Most of this information is standard to L<sup>A</sup>T<sub>E</sub>X.

### 3.1 Intra-chapter divisions: Sections

Section headlines are \Large and in the standard font. Compare them to subsections below.

#### *3.1.1 Subsections: Wow! Italics!*

Yes, italics. You may now dance. Isn't it funny that upright letters are called "roman" while slanted letters are "italic". That's like Italian, and Romans are Italians too. What gives?

#### *Subsubsections: Smaller and smaller*

Subsubsections are allowed, but are not numbered and don't appear in the table of contents. Likewise, you can use the next level of sectioning.

*Paragraphs* These divisions are unnumbered and do not appear in the Table of Contents.

*Subparagraphs* This is the finest division possible. It's also unnumbered and omitted from the Table of Contents.

## 3.2 Let's do some math

Let's look at an equation:

$$\partial f t = f(t) \quad \text{subject to} \quad f(0) = c. \quad (3.1)$$

We've used the `\newcommand` defined in the preamble of `dissertation.tex` to produce the derivative. You can get a second derivative like  $\partial^2 f t^2$  by adding some sneaky superscripts. Fancy.

More advanced equation formatting is available in the AMS environments. See the guide `amsmath` user's guide. Here are some nice examples of cases people usually have trouble with.

An equation that's too long for one line — use `multline`:

$$\begin{aligned} a + b + c + d + e + f + g + h + i + j + k + l + m + n + o \\ = p + q + r + s + t + u + v + w + x + y + z. \end{aligned} \quad (3.2)$$

An equation with multiple parts and one number per line — use `align`:

$$a_1 = b_1 + c_1 \quad (3.3)$$

$$a_2 = b_2 + c_2. \quad (3.4)$$

The same equation, set inside the `subequations` environment:

$$a_1 = b_1 + c_1 \quad (3.5a)$$

$$a_2 = b_2 + c_2. \quad (3.5b)$$

Notice that by clever placement of labels, I can reference the pair via (4), the first (3.5a), or the second (3.5b). One number for multiple equations can be accomplished using the `split` environment:

$$\begin{aligned}
 a &= b + c - d \\
 &\quad + e - f \\
 &= g + h \\
 &= i.
 \end{aligned} \tag{3.6}$$

People often struggle under the complicated and ugly 'eqnarray' environment. Don't do it! The AMS ones are easy. Other stumbling blocks are cases:

$$a = \begin{cases} b & \text{for } x > 0 \\ c & \text{otherwise,} \end{cases} \tag{3.7}$$

matrices:

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, \tag{3.8}$$

and evaluation bars:

$$a = \left. \frac{\partial u}{\partial x} \right|_{x=0}. \tag{3.9}$$

See the source file for details.

When we reference an equation with something like `\eqref` (3.1). If you click on the above references in the PDF, your viewer should scroll up to the above equation. It's handy. Labels and references may be attached to all sorts of objects. There is a `\label` attached to this chapter (it appears at the top of this file), and we may reference it by `(Chapter^{\ref{chap:example}})`, producing "Chapter 3". By default these ref's are hyperlinked as well. Later, we'll see labeled and referenced figures and tables. Particular pages may be labeled with standard `\label` commands in the text and referenced via `\pageref`.

You might also like the links from \cite commands to the corresponding bibliographic entry. Go look at this imaginary book by Stephen Colbert ?. If you’re not a bibtex expert, look in `mybib.bib` at the @ARTICLE that generated this entry. It shows an example of accents on author names and how to preserve upper-case for letters in the title. Other entries show the use of the `and` keyword between author names. You may order a particular author’s name as either “first last” or as “last, first”. The actual format of the bibliography is controlled by the `\bibliographystyle{}` command in `dissertation.tex`.

### 3.3 Table of Contents Behavior

Now is a good time to look back at the Table of Contents. Notice that you may click on entries here to warp to the corresponding document location. In Adobe Acrobat and many other viewers, you can open a ‘bookmarks’ pane. This should be populated with named and numbered sections and subsections identical to the Table of Contents.

### 3.4 Figures and footnotes

Figures are set with very little space between the caption and the bottom of the included graphic. This is because most graphics programs pad the edges of images. If you find the spacing unsatisfactory, you may always add a bit manually. The text of the caption is single-spaced, and the word ‘Figure’ is set in small caps. See Fig. 7.3. Notice the use of the nonbreakable space “~” between the “Fig.” and the reference. Figures (and tables) are examples of ‘floats’ — objects that L<sup>A</sup>T<sub>E</sub>X decides where to place for you. You may give L<sup>A</sup>T<sub>E</sub>X some hints. Change the `\begin{figure}[tbp]` to a `\begin{figure}[b!]` to restrict the placement. Inside the [ ], you can put the following



FIGURE 3.1: Longer caption for actual body of dissertation. Figure captions should be **BELOW** the figure.

- t Allow placement at the top of the page
- b Allow placement at the bottom of the page
- h Allow placement 'here', in the middle of the page close to the text that the figure environment appears next to.
- p Allow placement on a separate 'floats page' that has no body text.
- ! Tighten the screws on the placement algorithm. This doesn't force things to happen as you say, but it makes it much more likely. Be careful: the bang option can cause figures to appear above the chapter title and in other bad locations.

Notice that each entry just changes what is *allowed*, but no preference among the entries can be registered. The default is [tbp], which is a very good default for a

document like this, since floats in the middle of a page trap too much whitespace for double-spaced text. There is also a prohibition against having a page with more than 75% float. Instead, long floats will get kicked over onto float pages. Float pages are often a bad idea, as the creation of one will often cause a domino effect, with all subsequent figures appearing on float pages themselves, and all these float pages appearing together at the end of the chapter. (This is more like sinking than floating.) Avoid this by physically moving where the figure environment appears in your source file to an earlier location. Don't be afraid to put the environment before the first spot you reference it! Many float problems can be solved by a combination of relocating the figure environment and a little fiddling with the [ ] options.

Also notice the order of the graphic, caption, and label. If you deviate from this, strange things can happen. The caption of this figure shows the use of short captions (inside []). These captions appear in the List of Tables, while the captions appear in the body. If you omit the [ ] short caption, the long caption will be used in its place.

Another technical note: since this style sheet is designed for processing by pdflatex, \includegraphics looks for PDFs, PNGs, and JPGs instead of the usual PS, EPS, and TIFF formats. You can convert existing graphics with a variety of tools. PDF graphics are preferred, as they scale nicely. The open-source software Inkscape runs on Mac OSX, Windows, Linux, and some UNIX variants. Versions 0.46 and beyond have great support for creating and editing PDFs. It can even be used to convert other docs.

### *3.4.1 List of Figures*

If you've put even one measly figure in your document, grad school rules say you need a List of Figures. It's automatically generated for you if you do a \listoffigures in the master file (heck, it's there right now). Go look at the list of figures now. You

Table 3.1: Long table caption appears on in the body text. See the short caption in the List of Tables. Table captions need to be ABOVE the table.

Numbers	Letters	Symbols
1	a	†
2	b	‡
3	c	×
4	d	#

should be able to click on the figure number to warp to the figure. You'll also see the result of the 'short caption' used above.

### 3.5 Table example

Just to make sure tables are formatted correctly, here's an example of a table float, see Table 3.1. You should note that [b] formatting (`\begin{table}[b]`) can cause floats to appear under the footnotes. Try changing it here and see the ugliness. Tables are identical to figures, except that the word 'Table' appears in the caption and its entry is in the List of Tables instead of the List of Figures.

#### 3.5.1 Footnotes

Footnotes are allowed.<sup>1</sup> They are numbered with arabic numerals inside each chapter and appear at the bottom of the page.<sup>2</sup> The little footnote numbers are also hyperlinks. Try clicking them. You should place the footnote command immediately following the period of the sentence it is attached to. Any spaces or newlines will result in strange spacing between the number and the sentence.

---

<sup>1</sup> But, you should probably just work them into the text since it's annoying to jump around when reading.

<sup>2</sup> ... rather than the end of the chapter or the thesis. Those would properly be endnotes, I guess.

### 3.6 Corner cases in formatting, such as very very very long section titles. Man, this goes on forever.

Common corner-cases involve very long titles (like above). In these cases, the long titles are set single-spaced both here and in the Table of Contents.

#### *3.6.1 Figure and Table caption cases are neat, and this is an absurdly long subsection heading*

Consider the shield logo again with an absurd caption, as in Fig. 3.2. Also examine the new table, Table 3.2. Both of these have been forced onto a floats page so you can see what that looks like.



FIGURE 3.2: The Duke logo again, but now with a really long rambling caption. This caption should be set single-spaced in the LoF and in the body text. What do you think about having graphics in the main directory of a project? I'd prefer them in a folder, then put 'foldername/picturename' as the argument to includegraphics.

Table 3.2: The same silly table again, but with a really long caption.

Numbers	Letters	Symbols
1	a	†
2	b	..
3	c	×
4	d	#

# 4

## Nonsense text for layout proofing

Enjoy some Lorem Ipsum text! This should create about two full pages of text so you can verify the margins are correct (especially if you're doing two-sided).

### 4.1 Lorem Ipsum

  Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Sed vitae leo. Pellentesque quis nisi id orci consectetuer posuere. Quisque malesuada rhoncus dui. Vivamus mi. Mauris commodo. Phasellus lacus magna, feugiat ac, blandit ut, rutrum id, massa. In consectetuer magna vel justo. Cras eu diam. Nullam tortor turpis, bibendum non, consequat ac, tincidunt non, nisi.

  Curabitur sagittis dignissim arcu. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Vestibulum ullamcorper. Curabitur faucibus euismod nulla. Vivamus sagittis. Sed fermentum neque a risus vestibulum convallis. Morbi id massa ut arcu mollis commodo. Aliquam erat volutpat. Pellentesque fringilla pellentesque nisi. Morbi tristique ornare libero. Vestibulum turpis sapien, iaculis ut, cursus non, condimentum in, tortor. Aenean vehicula. Integer egestas tincidunt erat. Aenean euismod ante vel lectus. Duis ac sapien vel erat eu-

ismod aliquet. Vivamus tempor placerat nibh. Curabitur pharetra, orci consequat pulvinar ultricies, orci enim tempor augue, non lacinia orci nisl et nibh. Nunc gravida dictum turpis. Duis sollicitudin commodo massa. Nam ac nunc. Fusce sodales posuere velit. Nunc ullamcorper sodales urna. Donec consecteturtuer accumsan ante. Morbi feugiat rutrum mauris. Praesent malesuada auctor est. Pellentesque quis odio non nulla ornare imperdier. Aliquam dapibus. Suspendisse posuere, magna in molestie varius, ipsum velit rhoncus nisi, nec bibendum pede mauris in urna. Morbi purus lectus, molestie quis, laoreet id, tincidunt at, ligula.

Praesent sit amet libero id arcu adipiscing tristique. Quisque libero erat, bibendum nec, malesuada in, gravida et, urna. Phasellus molestie vulputate nisi. Nullam massa magna, dignissim ac, accumsan a, scelerisque eu, erat. Nam tellus augue, tempus nec, molestie sit amet, rhoncus vel, libero. Vestibulum at neque. Aliquam laoreet tincidunt mi. Ut laoreet ligula ac urna. Nullam nisl pede, posuere id, dictum a, fermentum vitae, turpis. Nulla ante mauris, euismod et, mollis eu, tempor in, quam.

In pede augue, elementum varius, tincidunt in, condimentum ut, erat. Etiam vulputate faucibus velit. Aliquam porttitor. Nam fringilla adipiscing nisi. Sed in magna. Aenean non ante. Aenean facilisis, nunc sed aliquam porta, magna est aliquam nisi, vitae semper turpis orci ac dolor. Praesent nec tellus. Cras vulputate rhoncus sem. Curabitur eu mi. Mauris euismod lacinia nibh. Suspendisse eget sapien et nunc accumsan elementum. Nulla dapibus. Donec interdum elit mattis velit imperdier aliquet. Mauris feugiat, ante vel faucibus rutrum, eros mauris sollicitudin neque, ut varius diam ipsum et massa. Nullam non nisi sit amet tortor rhoncus molestie. Cras consecteturtuer condimentum ante. Phasellus fermentum risus fermentum turpis. Mauris dignissim iaculis sem. Fusce nisi lorem, viverra id, auctor et, scelerisque ut, massa. In hac habitasse platea dictumst. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Aliquam pulvinar

neque ac dolor.

## 4.2 More nonsense

  Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Sed vitae leo. Pellentesque quis nisi id orci consectetuer posuere. Quisque malesuada rhoncus dui. Vivamus mi. Mauris commodo. Phasellus lacus magna, feugiat ac, blandit ut, rutrum id, massa. In consectetuer magna vel justo. Cras eu diam. Nullam tortor turpis, bibendum non, consequat ac, tincidunt non, nisi. Curabitur sagittis dignissim arcu. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas.

  Vestibulum ullamcorper. Curabitur faucibus euismod nulla. Vivamus sagittis. Sed fermentum neque a risus vestibulum convallis. Morbi id massa ut arcu mollis commodo. Aliquam erat volutpat. Pellentesque fringilla pellentesque nisi. Morbi tristique ornare libero. Vestibulum turpis sapien, iaculis ut, cursus non, condimentum in, tortor. Aenean vehicula.

  Integer egestas tincidunt erat. Aenean euismod ante vel lectus. Duis ac sapien vel erat euismod aliquet. Vivamus tempor placerat nibh. Curabitur pharetra, orci consequat pulvinar ultricies, orci enim tempor augue, non lacinia orci nisl et nibh. Nunc gravida dictum turpis. Duis sollicitudin commodo massa. Nam ac nunc. Fusce sodales posuere velit. Nunc ullamcorper sodales urna. Donec consectetur accumsan ante. Morbi feugiat rutrum mauris. Praesent malesuada auctor est.

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# 6

## Background

An experiment was conducted to compare the difference in performance between 3 groups that use different training program as explained in the previous chapter. The performance of each participant was measured through representative figures that summarizes the swiftness in control and the ability to cope with emergency situation. The objective of this experiment was to ascertain whether learning about both Nudge Control and Navigation Control helps in learning progress and emergency situation handling.

### 6.1 The Status of UAV

Unmanned Aerial Vehicle(UAV) indicates aircraft without a human pilot aboard. Commonly known as drone, UAV started to get its popularity since . There could be many reasons to explain the current trend in drone, but the popularity and demand for commercial drones explain easy accessibility by people. It is as common as smart devices.

Although it is more famous as a recreational device among general public, it has been proving its importance in various fields. The feature of no human pilot enables

the replacement of human workforce in dangerous environment. Oil, nuclear reactor, examination and explore, reconnasiance,

In these missions, the success of mission relies on the operator's ability. It is different from aircraft pilot. It requires different ability. Although relatively easier than aircraft, still requires a certain virtue (???? can use human's sense)

?? : no human pilot(no risk in human life, no ?? involved), small, relatively cheap,

## 6.2 Levels of Automation

## 6.3 Training Program

## 6.4 Learning Curve

## 6.5 Reasoning Under Uncertainty

# 7

## Training Program

This chapter explains about the 3 different training programs to be compared through experiment. 2 versions of drone controlling applications are prepared for this purpose. One is (electronic) Nudge Control, designed for manual control. The other is Navigation Control, used for more high-level control. These applications are coded for the Android platform in Java. Participants in group 1 were trained and learned about Nudge Control only, those in group 3 were trained using Navigation Control only, and those in group 2 were trained using both Nudge Control and Navigation Control.

### 7.1 Application Interface

#### 7.1.1 *Nudge Control*

Nudge Control gives an operator full control over a drone by allowing fine-grained maneuver. Figure 7.1 shows Nudge Control interface. An operator can easily check the current drone's battery status by looking at the battery gauge located in the middle of the screen(the red box 1 in figure 7.1a), so that the operator can keep track of the drone's health during navigation and allow the operator to report to



FIGURE 7.1: Nudge control application interface

experimenters immediately should the battery run out. Next to the gauge is the panel displaying flight time so far since takeoff, allowing an operator to keep his/her record in mind(box 2). Altitude indicator, placed next to the flight time panel, provides a true height of the drone’s current position from a specific ground reference level (not sea level, box 3). It gives a numerical information on the drone’s height, which greatly helps when crossing certain types of obstacles like bars and tunnels.

An operator controls a drone by using 2 joysticks located next to the main camera window. The right joystick(box 8) is responsible for lateral movement, without altering the current altitude. The direction of movement is not just limited to straight-line or diagonal movement, but is more flexible, reflecting drone’s flexible movement. It adds an much more freedom when it comes to control because an operator does not always have to align the drone’s heading with the direction it is headed for. The middle bar in the left joystick(box 7) changes altitude, and 2 buttons marked with respective arrows(box 5 and 6) cause the drone rotate in the corresponding direction.

An operator can get information on the surroundings through live camera stream(box 9), and also check the current position of the drone in the mini-map placed at the bottom-left corner of the screen(box 10). The position is marked by red drone icon,

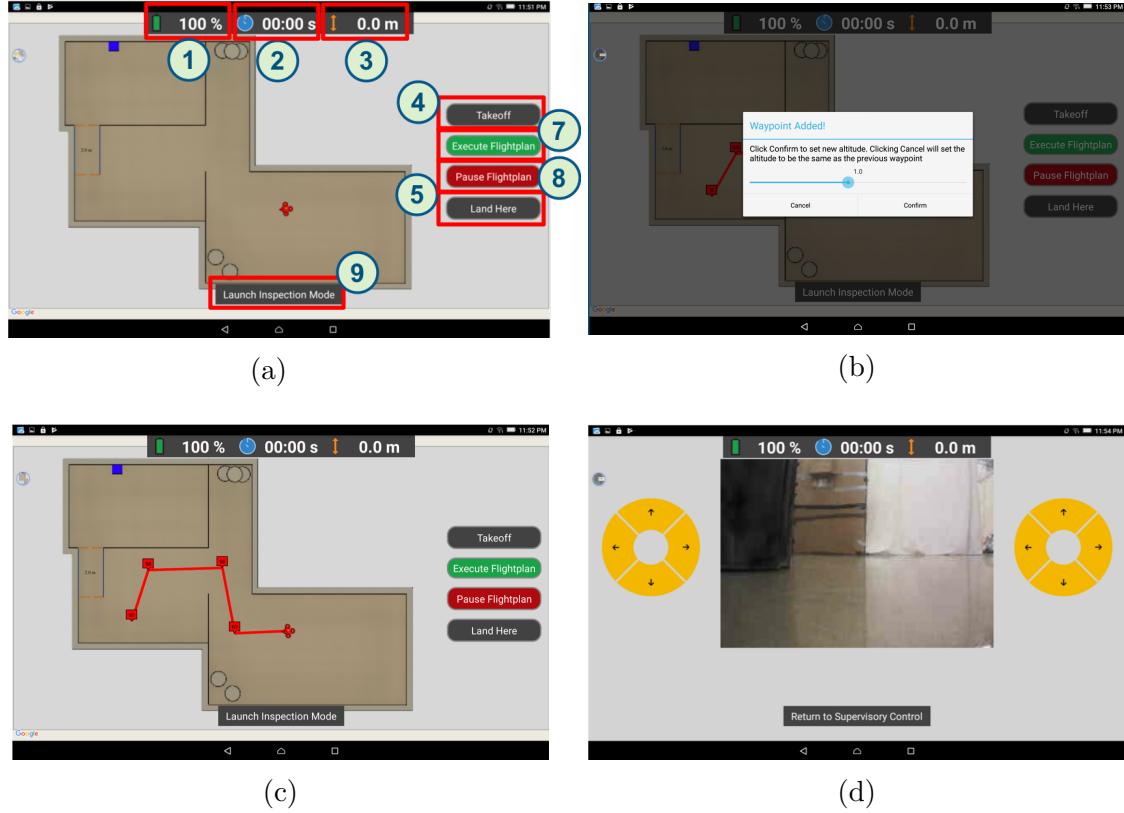


FIGURE 7.2: Navigation control application interface

and it is updated live. The main camera and mini-map frames can be swapped for the operator’s convenience using the swap button(box 11). The resulting configuration is shown in figure 7.1b.

### 7.1.2 Navigation Control

In Navigation Control, an operator does not have to worry about micro control. Instead, an operator sets waypoints and executes the customized flight plan represented by waypoints. Figure 7.2 shows Navigation Control interface. First, as usual, an operator can monitor the battery status, flight time, and altitude through the relevant panels positioned at the top of the screen(box 1,2, and 3 in figure 7.2a). On a map that occupies the entire screen where an operator can see the basic layout of

the environment and known obstacles, the operator can create a waypoint by tapping and holding a finger at the desired spot. Along with the position of a waypoint, an operator can also specify the altitude of a waypoint(figure 7.2b). Once the waypoints have been set as in figure 7.2c, pressing the Execute Flight Plan button(box 7 in figure 7.2a) will cause the drone to fly through the waypoints autonomously and sequentially (in the order of creation) as indicated by the path on the map. The drone moves in a straight line considering the difference in altitude and position between 2 adjacent waypoints, and it pauses and hovers temporarily (about 1s) over each waypoint until it resumes navigation to the next waypoint in order to eliminate the inertia effect when turning around.

Since Navigation Control does not offer the feature of avoiding obstacles autonomously and only directs the drone through waypoints in a straight line, it is entirely up to operator's responsibility to avoid any obstacles by setting proper waypoints. As such, an operator can force the drone to pause at any time during navigation using the Pause Flight Plan button(box 8), and change/remove the existing waypoints. Furthermore, Navigation Control also allows the operator to check the surroundings through camera by switching to Inspection Mode using the Launch Inspection Mode button(box 9). The resulting screen is shown in figure 7.2d. Inspection Mode is similar to Nudge Control in terms of function and how it works, but it has a different purpose. It is intended to control camera work, and thus its main purpose lies in checking surroundings, not in maneuvering the drone. For this reason, unlike Nudge Control, Inspection Mode does not provide mini-map where an operator can check the location of the drone relative to the environment. Actually, an operator can control the drone manually using Inspection Mode, but the drone's speed is much slower compared to Nudge Control, and the direction of the lateral movement is so limited that it is much harder to navigate with Inspection Mode than Nudge Control. An operator can freely switch back and forth to Inspection Mode at

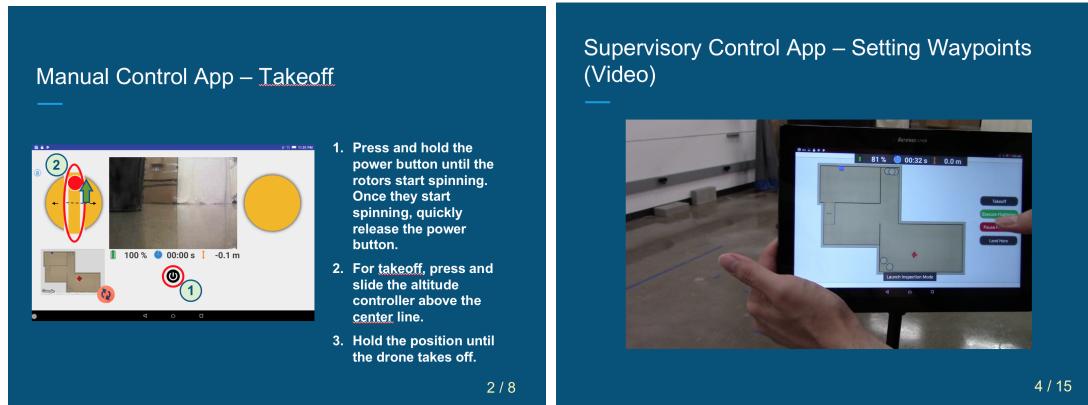


FIGURE 7.3: Powerpoint slides for training program

any time during navigation, and mix it with Navigation Control.

## 7.2 Training Modules

Training program consists of 6 + 1 modules. Module 1 briefly explains about the basic concepts and knowledges on drones. Module 2 introduces the interface of the corresponding application, which is different according to the group a participant belongs to. Module 3 explains how to take off and land a drone. Module 4 teaches on how to navigate a drone. Module 5 explains on how to control the camera installed on a drone. Module 6 gives general warnings and advices in case of emergency situations and explains about general approach to emergency handling and possible scenarios that could happen.

Each of these first 6 modules contains self-paced learning part where participants are given powerpoint slides to study. Then they are given multiple choice quizzes, to ensure they do understand the materials before proceeding to the next module. Also, module 3 - 5 include hands-on practice part, where the participants are given opportunities to practice control skills based on what they learned from powerpoint slides. To facilitate training, powerpoint slides include video clips on how to manipulate the application.

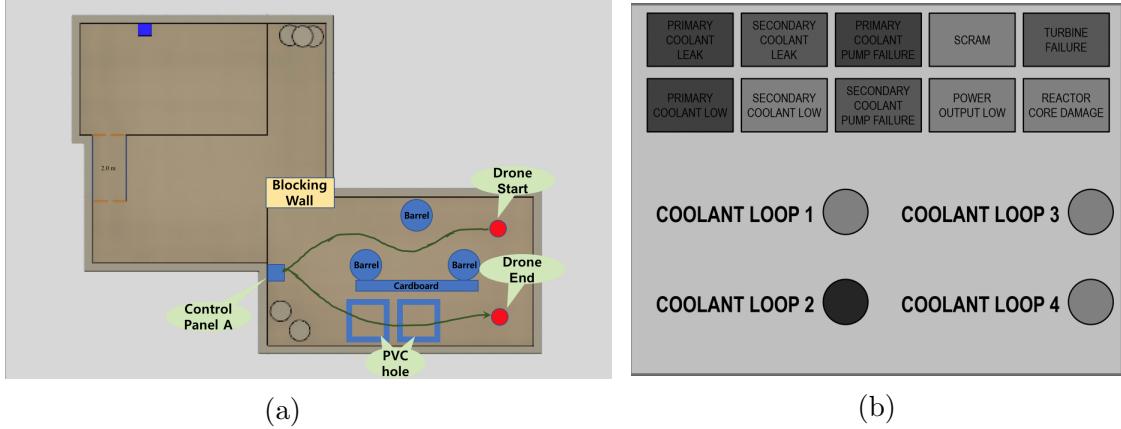


FIGURE 7.4: Environment settings for checkride

The last module is Checkride, the final flight practice where participants are asked to complete a full mission rather than focusing on a specific aspect of drone control unlike previous modules, in a miniature version of the test environment. Checkride environment is not the same as the test environment, but is still designed to train participants in preparation for types of obstacles they may encounter during the test mission. Also, this module prepares participants for the tasks they will have to do during the test mission.

Figure 7.4a shows Checkride settings. In the checkride module, an operator is asked to fly a drone to reach Control Panel A, read signs on the control panel (figure 7.4b), and then safely fly the drone back to the designated spot while avoiding obstacles. For training purpose, they are not allowed to fly over the barrels or PVC gates, which is obviously the easiest solution to avoid obstacles. Also, they are not allowed to proceed to next step until they report correct information on the panel (colors of figures). Participants are given maximum 3 chances to complete the mission, due to the limited supplies of drone batteries. There is no time limit.

The difference in training program between 3 groups lies in the fact that while group 1 and group 3 learns about how to manipulate Nudge Control and Navigation

Control, respectively, group 2 learns about both application. This means that people in group 2 are also trained to use both Nudge Control and Navigation Control during hands-on practice and Checkride.

# 8

## Performance Comparison

An experiment was conducted to compare the difference in performance between 3 groups that use different training program as explained in the previous chapter. The performance of each participant was measured through representative figures that summarizes the swiftness in control and the ability to cope with emergency situation. The objective of this experiment was to ascertain whether learning about both Nudge Control and Navigation Control helps in learning progress and emergency situation handling.

### 8.1 Participants

The subjects were recruited on Duke campus through recruitment emails and flyers, but not just limited to students. Only those over 18 with 20/20 or corrected to normal vision (i.e., with glasses or contact lenses), no neurological disorders, seizure disorders, head injury or any physical impairments that would prevent them from using conventional computer input device were accepted to participate. As a result, 38 people were recruited in total.

## 8.2 Procedure

Participants scheduled a time at their convenience through scheduling website. They were randomly assigned to one of 3 groups, along with 2 experimenters, named experimenter A and B hereafter. 5 experimenters were listed in the rotation and 2 of them were assigned to each participant. Experimenter A is mainly in charge of the interaction with the participants - guiding the participants through experiment, giving instructions in each training module and test missions, and answering the questions they ask. Experimenter B is responsible for system management - drone setup, battery change, repair in case of possible breakdown, and preparation of different environment settings between modules 3 - 5, checkride and test flight.

Each participant performed the experiment individually with these 2 assigned experimenters. The experiment ran between 60 to 150 depending on the type of group and the difference in the speed of individual progress. The participants were first asked to sign a printed copy of consent form, IRB Personal Data Disclosure Form (for monetary compensation) and then asked to complete a preliminary demographic survey using a desktop which asked about experiences with computer games, tablet computers, remote controlling devices and drone operation. Once completing a survey, participants proceeded to start training program, as explained in the section 3.2. After training, participants were briefed about task scenario of test mission from experimenter A as explained in the section 3.3.2, while experimenter B is preparing the setup for test mission. In test mission, experimenter B took the role of changing the settings for Door A and B once the participants successfully reached Room C. If drone crashes at any point during flight, test was stopped. Otherwise, test continued and finished once the participants came back to the original location without crash. Either way, the participants were asked to fill out post-experiment survey after the test mission. Finally, the participants were debriefed about their performance in the

test mission from experimenter A, and were given monetary compensation (\$40, \$50, \$25 for group 1, 2, 3 respectively. The amount is decided to reflect the estimated average runtime) to thank them at the end of the experiment.

To minimize the potential bias coming from different experimenters involved, all instructions are documented. All experimenters are instructed to read out written scripts, and follow the exactly same experiment procedure which is documented as todo list in detail. Although experimenters are allowed to answer questions to their knowledge passively, they are refrained from giving additional, voluntary comments or lectures of any kind. To ensure uniformity further, each experimenter went through at least 3 practice experiments to train themselves and become acquainted with the experiment procedure.

### 8.3 Task Scenario / Test Mission

Before beginning the test flight, the participant is first briefed about the assumed task scenario. The nuclear reactor has been partially destroyed due to an earthquake, and it is unclear how compromised the containment of radioactive material has become. The building needs to be examined to determine the extent of the damage, but due to the risk of sending humans into this environment, a UAV will be sent instead. Now, the participant is then asked to fly the UAV into the building to reach a control panel, and to read key information on the status of the reactor on this panel. Then, the participant is to fly the UAV safely back to the takeoff location for recovery of the vehicle.

Although the participant is provided a general map of the building layout containing major features such as walls, hallways, and doors as shown in figure 8.1, the map is not perfect in that there could be unexpected obstacles or barriers that do not appear on the map due to damage, which is also advised to the participant. The participants are also noted that right after entering Room C, there should be some

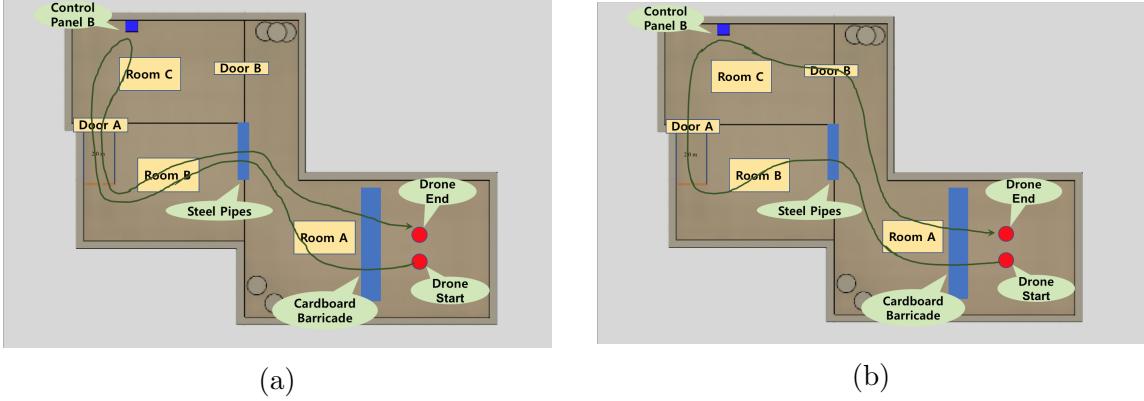


FIGURE 8.1: Environment settings for test mission

changes in the environment. Then the participants are told that they might have to find another evacuation path different from the passage through Door A due to building damage. The changes are signaled by a loud explosion sound. Following the sound, Door A will be blocked, while Door B will be open (which has been originally closed). Possible flight plans before the environmental change and after the change are shown in figure 8.1a and figure 8.1b, respectively.

Unlike in Checkride, participants are given only one opportunity to complete the mission. If the drone crashes, the test is considered Fail, unless the crash resulted from either system failure or unexpected interruption in the environment. If they fail to report the correct information on the panel, they are consistently given chances to make correct guess, instead of concluding it as Fail. Once the participant successfully flies the drone back to the original takeoff location and retrieve the drone, the test is marked as Pass. As in Checkride, there is no time limit.

## 8.4 Apparatus

A tablet computer (Lenovo Tab 2 A10-70) is used as hand-held device for the display of the interface and control of the drones by the participant. The type of the UAV

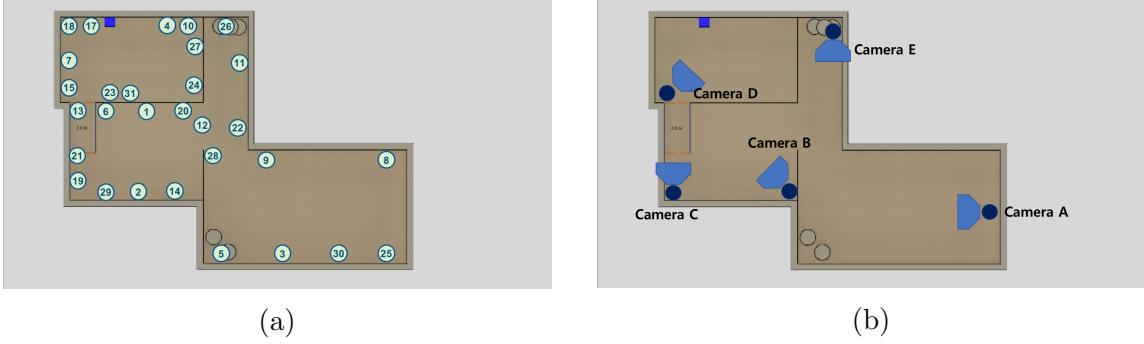


FIGURE 8.2: Camera configuration

used in the experiment is a Parrot AR 2.0 UAV, and open source software Paparazzi is used to customize the drone's settings. To track the drone's location, 26 Vicon Vero cameras and 4 Vicon Vantage cameras (for better coverage) are installed in the experiment environment. The VICON camera configuration is shown in figure 8.2a. To guarantee the accuracy, the cameras are calibrated regularly for every 4 - 5 experiments. Other than VICON cameras, 5 digital recording cameras are placed as shown in figure 8.2b to record the drone's movement for later analysis.

## 8.5 Data Collection

Demographic and post-survey data were collected electronically through Qualtrics. At the end of each experiment, experimenter A filled out experimenter report and submitted to Qualtrics as well. The experiment report is a summary on what happened during the experiment, including crash report and information on the experimenters of the day. Participant's interactions with the controlling device were recorded as a form of screen capture video. Drone's movements were recorded using 5 video cameras placed all over the room. Also, drone's exact location at every instant were logged to a CSV file consisting of  $x, y, z$  coordinates relative to VICON system calibration.

## 8.6 Performance Metrics

The raw video data obtained from 5 recording cameras and tablet screen capture were examined to get quantitative measures of interest.

### 1. Pass and Fail

If a participant completed the mission without any crash, the test was marked as Pass. If a participant crashed and the drone fell down as a result, we first examined the reason using recorded video files right after the crash. If it turned out that the crash was clearly due to the operator's fault, the test was marked as Fail. If it was clear that the crash resulted from system malfunction such as battery runout or unstable connectivity of any kind between devices, the participant was given a chance to resume the test mission from the point of crash. In this case, the test was marked as either Pass or Fail depending on the final result, but also asterisked for reference in later analysis. If the reason of crash was unclear at the time of experiment, the participant was allowed to resume the test from the point of crash, while being asterisked. If the crash turned out to be because of the user's fault in the later examination, the data was considered normal and the asterisk was removed.

### 2. Mission Completion Time

Measured total completion time taken from take off at the starting point to landing at the landing point. This assesses the operator's general ability to navigate a drone without hitting into obstacles with different difficulty levels.

### 3. Time taken from start to shaft

Measured a portion of time taken from take off at the starting point to the ventilation shaft in room B. This assesses the operator's ability to control drone in a normal environment where the space is wide open with sporadic obstacles

that are not hard to avoid.

4. Time taken to pass through ventilation shaft

Measured a portion of time taken to pass through the ventilation shaft in room B. This assesses the operator's ability to control drone in a tight, limited space where cautious control with patience is strongly required because the passage through ventilation shaft is narrow in width and height.

5. Time taken from explosion to finish

Measured a portion of time taken from the moment of explosion to landing at the landing point. This assesses the operator's ability to deal with unexpected situation, as the operator has to find another evacuation path different from the one he/she used for the entry to room C. This incorporates the ability to find another exit by examining surroundings using camera, and the ability to evacuate through the passage that does not appear on the map.

# 9

## Results and Discussion

In order to compare the difference in performance between 3 groups, a total of 38 subjects were recruited and went through experiments individually by following the procedure described in the previous chapter. Subjects in group 1 used Nudge Control in the final mission, while subjects in group 2 and 3 used Navigation Control in the final mission. Of the 38 subjects, 4 were completely excluded from analysis. For 2 of them, the data was not collected successfully because of the fault made by the experimenters involved. The other 2 subjects were excluded because they showed significantly poor performance compared to the others. Both of them could not even make through the very first obstacle (the cardboard barricade) in Room A while the others passed through at least the second obstacle (steel pipes), so they were labeled as outliers. As a reference value of significance level for any statistical test,  $\alpha = 0.05$  is used throughout this chapter.

### 9.1 Data Label

Out of 38, data from 34 subjects were used for analysis (12 / 12 / 10 for Group 1,2, and 3, respectively). For more reliable analysis, we labeled each data as either

Table 9.1: Data Label

Numbers	Group 1	Group 2	Group 3
Complete	10	8	8
Broken	1	1	0
Partial	1	3	2
Total	12	12	10

“Broken”, “Partial”, or “Complete”. Table 9.1 summarizes the number of data for each label.

Broken data is data where the drone landed prematurely due to battery depletion so the subject had to pause and resume flight after replacing the battery. In this case, the subject’s performance was estimated by adding 2 separate records while considering time unnecessarily spent on landing, takeoff and re-orienting before/after battery change.

Partial data is data where the subject’s performance might possibly have been affected by external factors (other than battery issue) that are not intended and unexpected. One of the examples is the case where Door A did not operate in a timely manner so it delayed the subject’s performance. The other cases are inflicted by system error that caused malfunction of drone operation which had nothing to do with the subject’s actions. Finally, Complete data is data where the subject did not suffer any kind of issue during test that could prevent normal operation.

For analysis purposes, all of these data were selectively used wherever appropriate. For example, when considering “Mission Completion Time”, only complete data were used. On the other hand, when dealing with “Time taken from start to shaft” metric, some of partial and broken data were included in analysis because those data were not corrupted until the drone reached the ventilation shaft. By doing so, we could maximally use our collected data while remaining as reliable as possible.

Table 9.2: Data Label

Numbers	Group 1	Group 2	Group 3
Pass	5	3	6
Fail	5	5	2
Total (Complete)	10	8	8

## 9.2 Subject Population

## 9.3 Analysis of Performance Metrics

### 9.3.1 Pass and Fail

Table 9.2 shows the number of Pass and Fail for each group. Group 3 was the most successful in terms of the ratio ( $6/8 = 0.75$ ), followed by group 1 ( $5/10 = 0.5$ ) and group 2 ( $3/8 = 0.375$ ). However, the generalized Fisher exact (Fisher-Freeman-Halton) test yields the p-value of  $p = 0.3017$  on the Pass/Fail ratio between groups, which indicates that statistically, there is no significant difference in the Pass/Fail ratio. Among 12 crashes, 8 crashes occurred near ventilation shaft as shown in Figure 9.1. This was not surprising because it was the most difficult obstacle to pass through. In Figure 9.1, red arrows indicate the drone's movement at the moment of crash, and numbers are subjects' IDs. Examining their screen recording, all of 8 subjects had hard time aligning their drone's to 40 inch-wide entry of the shaft mainly due to the delay in video stream and wobble caused by reflected winds from its rotors.

### 9.3.2 Mission Completion Time

Table 9.4 shows the summary statistics on completion time. Based on one-way ANOVA test, there was not significant difference in the completion time ( $p = 0.7438$ ). The best performers in each group showed a similar performance in terms of completion time while the worst performers did not; the worst performer in group 3

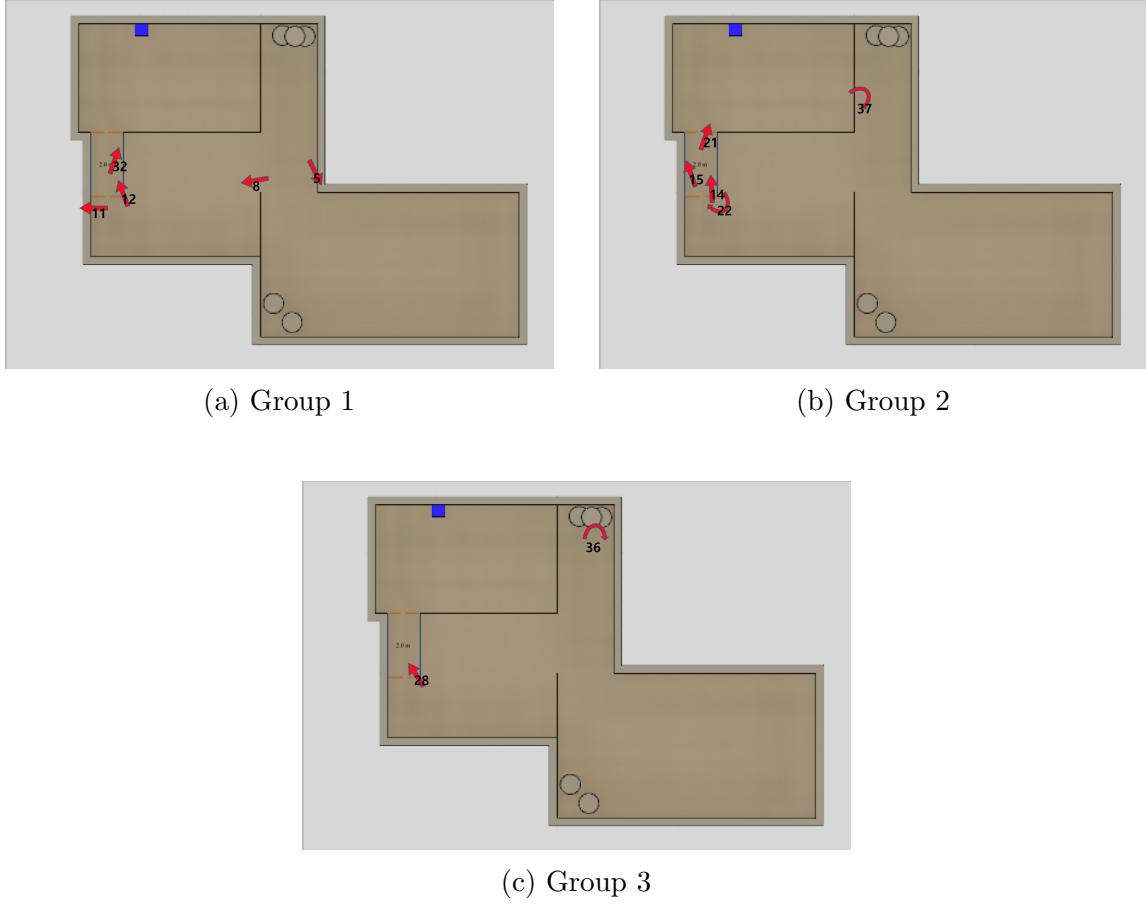


FIGURE 9.1: Crash Points

showed much better performance than those in other groups. Actually, the performance by subjects in group 3 was more consistent ( $sd = 1 : 05$ ) than other groups ( $sd = 2 : 10, 2 : 22$  for group 1, 2, respectively). Interestingly, it turned out that those who said that they had drone experience before showed the worst performance in each group. In group 1, all of 4 (out of 8 who were labeled as complete data) with drone experience ended up either Fail (3 out of 4) or the worst performer (1 out of 4, 10:05) in the group. In group 2, all of 3 (out of 5 complete data) were either Fail (2 out of 3) or the worst performer (1 out of 3) in the group. The worst performer in group 2 did considerably worse(10:00) than others in the same group(6:42, 5:23).

Table 9.3: Completion Time(mm:ss)

	Group 1	Group 2	Group 3
Average	7:49	7:21	6:58
Minimum	5:22	5:23	5:27
Maximum	10:05	10:00	8:06
Standard Deviation	2:10	2:22	1:05
Sample Size	5	3	6

Table 9.4: From Start To Shaft Time(ss)

	Group 1	Group 2	Group 3
Average	189.82	205.89	153.11
Minimum	95	93	54
Maximum	307	368	264
Standard Deviation	62.29	101.12	69.13
Sample Size	11	9	9

Similarly, in group 3, all of 3 (out of 8 complete data) were either Fail (1 out of 3) or the worst performers (2 out of 3, 8:00, 8:06) in the group. These observations suggest that those who had drone experience might have suffered from adaptation issue. None of them had experience with controlling drone relying on live camera, so their experience with drone with easy control coming from instant response with no live camera could have had negative impact on adapting to the new operation environment. If we only take into account the subjects with no drone experience, group 2 showed the fastest performance on average (6:02), followed by group 3 (6:26), and group 1(7:16).

### 9.3.3 Time taken from start to shaft

For this metric, there was no statistical evidence found that supports the difference between groups using one-way ANOVA ( $p = 0.3526$ ).

Table 9.5: Shaft Passage Time(ss)

	Group 1	Group 2	Group 3
Average	83.625	73	61.875
Minimum	29	29	23
Maximum	168	176	122
Standard Deviation	50.89	53.62	30.46
Sample Size	8	6	8

#### 9.3.4 Time taken to pass through ventilation shaft

Table ?? shows the summary statistics on shaft passage time. For this metric, no statistically significant evidence was found between groups based on one-way ANOVA ( $p = 0.6376$ ). On average, group 3 was the fastest (61.875) to get through the shaft, followed by group 2 (73) and group 1(83.625). After examining the screen recording of each subject in group 2 and group 3, who used the same application throughout the test, it was found that the increased time by group 2 came from the mixed use of Navigation Control and Inspection Mode. In group 2, 3 out of 6 subjects used both Navigation Control and Inspection Mode interchangably. The rest of 3 subjects used Inspection Mode only while in the shaft. On the other hand, in group 3, only 1 out of 8 subjects used both Navigation Control and Inspection Mode at the same time. The rest of 7 subjects used Inspection Mode while in the shaft.

#### 9.3.5 Time taken from explosion to finish

# Appendix A

## Populo Ornatus

Ut quando convenire scripserit mei, ut accusam noluisse eam. At scripta democritum quo, reque everti an qui, posidonium efficiendi ut mel. Pro an reque habemus, augue nemore conceptam in vim. Eu cibo ancillae takimata usu.

No vis albucius rationibus, eum doming ceteros constituto id. Ad suas zzril laudem cum. Natum mollis singulis vel te, ea elit imperdiet duo, odio inermis et eos. Nam ad vocibus tractatos, sit no vidisse diceret omnesque, mollis omnesque ea mea.

Ut est ridens principes scribentur, menandi interesset adversarium ius ut. Ut duo elit dissentias, at sea eleifend scripserit, eam nibh rebum definitiones an. Cum te quaeque epicuri mentitum, his elitr essent et, in sea habeo aliquid convenire. Quo euismod sadipscing definitionem an, ut duo iusto aliquando, graece appetere ne nec.

Consul imperdiet dignissim vis et, mei liber vidisse principes et, eu nam docendi voluptua democritum. Qui no dicat tamquam sanctus, saepe tincidunt no mel. Pro ignota albucius consetetur in, sint qualisque assueverit eam ut, vis graeco denique signiferumque ne. Sale appellantur contentiones eu his, pro magna ornatus ut, ad vidit omnesque euripidis pri. Sea congue moderatius in, his dicit suscipit no, mei

ei incorrupte assueverit. Nusquam nominavi et quo, idque delenit vim an, posse quaeque an mea.

Suas elitr lucilius sit an, aeterno persius vel eu. Mel at essent aperiam repudiare. Tale consul eum ne, eam no meis delenit iudicabit, an sint mutat pri. Nec no clita propriae pericula, duo explicari gubergren ei. Ne sit autem nominavi, te falli deserunt per. Quo tractatos suscipiantur ex, electram dignissim usu no, cu congue iriure vivendo vim.

At vero graeci fuissest his, quo similique persequeris ad. Ex est graece mandamus, antiopam voluptatum his ea. Assum appellantur mel an, ei mea veri commune efficiendi. Pri blandit urbanitas no. Nam ex enim reque, ut nec iusto regione ullamcorper, facer harum pertinacia mei ei. Erant veniam imperdierit an eam, veniam mucius equidem ius eu, at scripta labitur est.

Et quo soluta graecis accommodare. Tamquam mentitum menandri vim ut. Ut nec melius senserit, ut mei sale aequa. Prompta delectus mea te, fierent adipisci ad per, mei odio pertinax senserit et. Per ut persius singulis. Id qui malorum iracundia, semper conceptam cu sed.

Vis nominavi urbanitas intellegat an, ut numquam deseruisse sea. Et quo dico aequa adipiscing, ius ea commodo epicurei, eum cu nulla imperdierit efficiantur. Ea cum simul scripserit. Ius reque decore voluptaria ei, nec sensibus mediocrem eu, sit iriure vivendo ad. At munere maiestatis mel, ex persius honestatis nec. Nihil omnes definiebas duo cu, dicat ancillae no vix. No est prompta apeirian, mel ad quaestio theophrastus mediocritatem.

Persequeris intellegebat disputationi et nec, nam ne alia solum reque, ad pri clita appellantur reprehendunt. Clita iracundia ex cum, placerat invidunt dissentias ius id. Posit dictas recteque sed ne. At eam singulis recusabo intellegat, ius in probo clita posidonium, id atqui paulo rationibus pro. Ut elit mucius qui. Mel ea ubique nostrud takimata. Cu eos vituperatoribus temporibus feugait.

Per putent nusquam oportere cu, nullam discere te sea, an vix quot mutat. Cibo  
reque nostrum nec eu, justo mucius aeterno vis id. Facer tempor cu vix, ex saepe  
similique maiestatis qui, ne pro eripuit offendit. Id mel cetero efficiantur. Cum  
homero aeterno euismod an, vulputate definitiones ne quo.

Sed exerci incorrupte et, usu mundi molestiae reformidans in, at probo vocibus  
quo. Ex vel aliquip maluisset. Qui enim error an, molestie incorrupte an ius. Id  
maiestatis temporibus mei, tantas oporteat occurret id pri. Ei nam velit doming  
utroque.

Suas vituperata mel eu, ex veri omnes duo, an modo molestie ius. At vis moder-  
atius dissentias scripserset, nullam aliquam usu no. Cibo diceret sed an. Sea cu ridens  
convenire.

Pro prima blandit no. His ut dicit iriure oblique, eos meis urbanitas abhorreant  
te. Usu cu perpetua principes. Mutat utinam insolens id cum. Quo tale iudicabit  
conclusionemque ex. Eos id harum accommodare.

Vel legere liberavisse ut, et aequa timeam usu. Vis eu dico sanctus appetere, id  
vix graecis repudiare, ad persecuti mnesarchum mei. No atqui nemore deseruisse  
eum. Meliore accumsan accommodare in qui, an tation rationibus has, ea nulla  
aliquip euismod his.

Utinam ridens cum eu. Duo aliquam omnesque cu, sea elitr appetere ea. Mea no  
quas discere apeirian, munere hendrerit conceptam duo an, nec ad habeo tritani. Vis  
exerci volumus no. Omittantur reprehendunt no has. Malis accusata necessitatibus  
no nam.

No solet assentior ius, an ferri dissentiet pro, vix ad tantas offendit. Pro tollit  
consequat gloriatur ne, eu vix amet posidonium. Errem utamur veritus vix ea. Sed  
laboramus omittantur id, ut sonet voluptatum has, cu doctus iriure menandri eos.

Regione iudicabit ei per. Cum ea aliquip voluptatibus. Sit in partem explicari. Ne  
probo labores placerat mei. Ullum pertinax ea his, per cu persius impedit adipisci.

Fabulas ancillae dignissim ei his, ius no nulla melius suscipiantur, ne vel laudem eripuit gubergren.

Ei qui equidem adolescens. Has ad accusata urbanitas voluptatum, no pri ferri dicit. Ne qui veritus omittam neglegentur, usu et lorem audiam mediocrem. Vim falli dictas labitur cu, dolores laboramus constituto id has, sit ea sint summo utroque.

Mei graecis definiebas eu, ad his brute omittam elaboraret. Ridens laoreet eos ne, diam mnesarchum ne sea. Idque everti ea pro, erudit probatus patrioque eu has. Cum omnes gubergren ex, cum te noster offendit indoctum. Putant dissentunt duo ex, dicat etiam cu quo. Duo esse probatus complectitur ex, vitae eripuit nostrum no sed, cum odio veri reformidans ex.

Vide ipsum ei vel, at diam nominavi his. Etiam assueverit nam eu, ut habeo nusquam eleifend mei. Pro eirmod perpetua id, minim urbanitas usu no. Vim elitr nominati definitionem ex. Ex tollit quaerendum has, nonumy inciderint eos ne. Vis posse munere honestatis ut.

Eu ornatus meliore usu, enim aeque possim eu cum. Pri ad everti fabellas, at pro omnium convenire repudiare, ut mel hinc minimum. Eam et puto reque mollis. Sed ad ponderum lobortis, cu pro viris vitae. Est et iriure inimicus, eos eu laoreet feugait voluptatum, agam aliquando voluptatibus pro eu.

Ex tale eirmod nec. Illud conclusionemque ad his. Sit augue error in, eu mea labitur voluptua, labores ullamcorper vis te. No usu enim aperiri facilisi. Ad vis brute soluta fastidii, meis mundi iuvaret his ea. Has eu cibo rebum. Mundi numquam repudiare ei cum, pri dicam tritani recusabo ea, pri id appareat qualisque.

Eu facete perfecto nec, te vel tale choro petentium. Mel in essent quodsi, occurret corrumpit in pri. Est in fabulas similique elaboraret, in viderer delenit vim. Eu vel paulo graeco viderer. Et ius elit debet latine, ad vel ferri voluptaria appellantur.

Vis ad docendi albucius, ne nam sale prima comprehensam. Adhuc inani accusam ex vis. Utamur labitur adipisci nec ei. No persius conceptam adversarium pro, ei

dicunt officiis lucilius usu. Te pri petentium vituperata, vis at solum dicit quaeque, minimum delectus singulis ei vim. His te nibh patroque dignissim, qui ne euismod argumentum. Quo lucilius sensibus cu.

Est ea nihil debitibus deseruisse, mea ne malis nostrum. Vel cu doctus euismod disputationi. Eos ut harum habemus, minim verear maiestatis mei ut. Te nam mundi deseruisse sententiae, pri an nibh eros velit. Ne omnium torquatos ius. Sit id congue quaeque intellegebat, homero volutpat dissentient ne usu, ei elit vituperata reformidans eum.

Ut sed corpora accumsan, his cu vero iriure probatus. Ubique latine ea per, usu no erant facilisis. Augue diceret eruditii ea vel, in diam maiorum ullamcorper eum. Vel no iriure latine suscipiantur, cu nec omittam liberavisse disputationi.

Congue repudiandae delicatissimi ut duo, fastidii iudicabit ut sea, eum integre sadipscing an. Cu vel alii liber, ceteros nostrum expetendis per eu, ne congue gloriatur vulputate cum. Eius fierent pericula has cu. Ea has atqui perfecto. Pericula torquatos ius ei, convenire theophrastus id sea, in dicit facilis facilisis mel. Nam modo diam occurret an.

Ferri sensibus eloquentiam quo et, mel an nullam vituperata, mollis dignissim sententiae sit ne. An pro perpetua democritum, te eam feugiat delicata deterruisset. Per minim choro ad, prodesset voluptatum ea usu, ea tempor putent quo. Mazim facete scribentur ea sea. Ea pri doctus feugait, ius eu vituperatoribus menandri, dico munere ubique ne his.

Mel no assum nusquam intellegebat, ius platonem consulatu an. Populo ornatus in sea. Sea soleat salutatus ne. Quo error saepe adolescens at, id cum duis voluptatum. Per maiorum mentitum te. Quem iudicabit percipitur per ea. Qui aliquid eruditii ad, ne vix veritus scripserit.

An duo postea aliquip. Nusquam luptatum id vis. Vim no magna inani. Eos et agam aliquid ancillae, verear ponderum no qui.

# Bibliography

# Biography

Your biography is limited to one page and must contain

1. Full name
2. Date and place of birth
3. Every degree you've earned, including this one, and where you earned it from.

Mostly, that information is to narrow down which John Smith wrote that dissertation on the mating habits of sea cucumbers. Sexy!

You may also include

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