**Measuring Stress Using Computer Mouse Movements**

**Dylan Drein**

**13344741**

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Department of Computer Science

Maynooth University

Maynooth, Co. Kildare

Ireland

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Single Honours in Computer Science

Supervisor: **Kevin Casey**

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## Declaration

I hereby certify that this material, which I now submit for assessment on the program of study as part of **(add your degree here)** qualification, is *entirely* my own work and has not been taken from the work of others - save and to the extent that such work has been cited and acknowledged within the text of my work.

I hereby acknowledge and accept that this thesis may be distributed to future final year students, as an example of the standard expected of final year projects.

Signed: Date:

## Acknowledgements

## Abstract

Style

The abstract should be a microcosm of the full report.

The abstract must be self-contained, **without** abbreviations, footnotes, or references.

The abstract must be between 150-250 words.

The abstract must be written as one paragraph, and **should not** contain displayed mathematical equations or tabular material.

The abstract should include three or four different keywords or phrases, as this will help readers to find it.

Ensure that your abstract reads well and is grammatically correct.

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# **Chapter one: Introduction**

## Summary

Chapter 1 describes an overview of the existing work in this field and the motivation for carrying out this project as well as an outline of the approach and methodology used, from planning, through the implementation to the evaluation of the results.

## 1.1 Topic addressed in this project

This project uses computer mouse movement data collected over the 2014/2015 college year in and out of a college lab exam environment from 128.

The aim of the project was to use statistical analysis to determine whether or not information obtained from the raw data could be used to infer a relationship between user behaviour and stress levels and the environment in which the user used the computer.

Just over 19.6GB of raw mouse data was collected using a JavaScript based mouse event handler which stored the data in JSON format. The relevant data includes a UNIX timestamp for every mouse event, the nature of the event (mouseUp, mouseDown, mouseMove etc.), the X and Y coordinates of the mouse cursor on the screen (relative and absolute) as well as pseudonym identifiers for each user.

## 1.2 Motivation

The motivation for this project was to provide a passive, non-invasive and inexpensive model of detecting stress in users by monitoring their behaviour through computer mouse movements.

Previous research has strongly indicated that stress in the workplace has a negative effect on employee efficiency and employee performance, affecting work ethic and contributing to employee ‘burnout’. [1] Furthermore, in college students stress has been shown to negatively affect physical and emotional health [2] and strongly correlates with high levels of depression and anxiety. [3]

Although stress indicators are well studied and understood [4], measuring and collecting data in an unobtrusive and effective way is not always straightforward. [5] Electroencephalography (EEG) and electrocardiography (ECG) are proven methods in indicating stress in subjects [6], though they require specialised and expensive equipment to be in place before, during and after the stressful situation. Custom sensing hardware encounters similar issues, while self-report tools can provide biased and unreliable feedback based on the environment in which testing takes place. [5]

## 1.3 Problem statement

The project involved the parsing, categorising and analysis of vast amounts of data collected from 128 students over a college year. The raw data required a lot of cleaning before it could be effectively analysed in any meaningful way. The data also had to be parsed into 128 separate user files so that individual analysis could be carried out across the controlled situations.

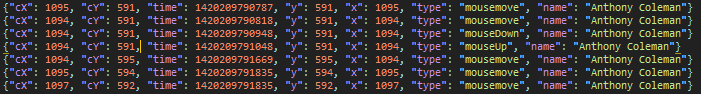
I had to determine what kind of information I hoped to glean from this data to achieve the aims of the project before I cleaned the data to know what to keep and what to remove. This involved identifying the relevant analytical methods that would be required to carry out the appropriate analyses and how best to apply these analyses to the data that I had.

Figure 1-1: Cleaned JSON data showing a mouse click event.

## 

## 1.4 Approach

### 1.4.1 Initial Decisions

Python was the programming language used to carry out this project, chosen for its widely supported and well documented statistical analysis and numerical packages, namely NumPy, SciPy, Pandas, scikit-learn for machine learning and matplotlib for graph plotting. Initially Project Jupyter’s IPython[7] command shell was used which offers an interactive browser-based development notebook, though as time went on the Windows command prompt was used as the predominant Python interpreter.

### 1.4.2 Designed Solution

Each of the metrics in section 1.5

### 1.4.3 Evaluation

Data was initially analysed by graphing its spread with histograms, scatter plots and box plots using matplotlib plotting software. Doing this allowed for further relevant analysis to be identified based on how the data looked visually and also allowed for tweaks and changes in the previous code to be made to better suit the data once it had been visualised.

In addition, descriptive statistics such as the mean, median, standard and variation were used alongside the visual analysis. This information was used to compare data between samples, allowing us to identify and test for correlation between in lab and out of lab conditions for each of the metrics highlighted in section 1.5.

Hypothesis testing was used to determine if corresponding metrics from in lab and out of lab environments were statistically different from one another. A student’s t-test was used to carry this out, using log transformations on data sets which were not normally distributed to normalise them. Where statistical significance was found, results from previous research was used as a basis for inferring stress based on the observed behaviour.

## 1.5 Metrics

Based on the spread of the data [**LINK TO WHERE IN DOC THIS IS DISCUSSED]**, relevant mouse movement sequences (hereafter referred to as *click sequences)* are limited to those which last for 1450ms and end with a *mouseDown* event or where another click sequence begins.

The relevant metrics that were obtained from the data and used for analysis were:

1. **Distance:** Both actual distance and optimal distances were calculated for each click sequence. Actual distance measured the real mouse path distance of each click sequence. Actual paths were made up of a collection of mouse event *‘mouseMove’* points and so the distances between these points were summed to approximate the distance travelled. Optimal distance was calculated as the Euclidean distance between the start and end point of the click sequence. [**CHECK WHAT FORMULA NUMPY NORM USES]**
2. **Time:** The duration of each click sequence was calculated in milliseconds.
3. **Speed:** The speed of each click sequence was calculated in pixels per millisecond (px/ms) and pixels per second (px/s).
4. **Click hover time:** The duration for which each user ‘hovered’ the cursor over the click point before clicking the mouse was calculated for each click sequence.
5. **Efficiency:** Efficiency of each click sequence was calculated by calculating:
6. **Overshoot:** The distance for which the user ‘overshot’ the target with the mouse cursor was calculated for each click sequence.
7. **X/Y-axis error:** The error was calculated for optimal and actual distance for the individual *x-y* components of each click sequence. This used the same method as (**1.**) though it measured the change in distance along each axis separately for each click sequence.

## 1.6 Project

# **Chapter two: Technical Background**

## Summary

## 2.1 Topic material

## 2.2 Technical material

Table 2‑1 Table of interest: Aspect of your implementation

|  |  |
| --- | --- |
| **Column description 1** | **Column description 2** |
| A | Text 1 |
| B | Text 2 |
| C | Text 3 |

Table 2‑2 Data sources used in your implementation

|  |  |  |
| --- | --- | --- |
| **Column description 1** | **Column description 2** | **Column description 3** |
| X | 22 | 33 |
| Y | 33 | 456 |
| Z | 17 | 22 |

# 

# **Chapter three: The Problem**

## Summary

The aim of the project is to create a system which analyses collected mouse movement data and identifies correlations between specific metrics outlined section 1.5. The raw data needs to be cleansed and prepared appropriately so that this can be carried out and the results need to be obtained in such a way that they can be statistically analysed to produce useful information.

## 3.1 Technology to use

## 3.2 Preparing the Data

1) ~~Remove irrelevant fields and~~ reverse [filereverse.py]

The JavaScript mouse tracking software compiles all of the mouse data for each user into a single log file. There are over 88 million mouse events in this log file with each event entry holding 11 fields. It will therefore be necessary to remove non-relevant fields and delete duplicate event entries as required.**[initialcleaning.py]**

One of the 11 fields recorded in each mouse event is the UNIX timestamp of when that event took place. In the log file, entries were saved from oldest to most recent. During analysis it will be necessary to read the data in line by line, starting with a mouse event and work

The serialised nature of the data based on the timestamp means it is straightforward to reverse this ordering and save the data from newest to oldest instead.

2) Break up into user files

3) Convert to CSV

## 3.3 Isolating Relevant Data

## 3.4 Calculating Metrics

## 3.5 Problem Analysis

# **Chapter four: The Solution**

## Summary

## 4.1 Analytical Work

## 4.2 Architectural Level

## 4.2 High Level

## 4.2 Low Level

## 4.2 Implementation

# **Chapter five: Evaluation**

## Summary

## 5.1 Solution Verification

## 5.2 Software Design Verification

## 5.3 Software Verification

### 5.3.1 Your test approach (i.e. unit testing, sub-system testing, system testing)

### 5.3.2 Your tests (e.g. scenarios, test cases, test data, etc.)

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### 5.4.4 Comparison with previous solutions (if relevant)

**Chapter six: Conclusion**

**Summary**

**5.1 Contribution to the state-of-the-art**

**5.2 Results discussion**

**5.3 Project Approach**

**5.3 Future Work**

# **References**

[1] W. U. Ali, A. R. Raheem, A. Nawaz, and K. Imamuddin, “Impact of Stress on Job Performance: An Empirical study of the Employees of Private Sector Universities of Karachi, Pakistan,” *Res. J. Manag. Sci. Res. J. Manag. Sci*, vol. 3, no. 7, pp. 2319–1171, 2014.

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[7] “IPython: A System for Interactive Scientific Computing Python: An Open and General- Purpose Environment,” 2007.

**Appendices**

## Appendix 1 Schematic of the hardware associated with this project.

## Appendix 2 Code developed for this project.

## Appendix 3 UML Class, Use Case and sequence diagrams for this project.

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| Appendix 4 Screen shots of the project implementation |
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