**2015 Summer Research Report**

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Introduction

We were tasked with analyzing data that came from Dr. Mellisa Beck in the psychology department. In her experiment, she used a machine to track the eye movements of participants while they were searching for a target on a map. There were two groups of participants. One group consisted of undergraduate psychology students, and the other consisted of navy pilots. The maps ranged from low global clutter to high global clutter. A target could either be in an area of low local clutter, high local clutter, or there might not actually be a target. The participants were asked to select if there was a target on the map they were looking at, and if there was, they were to click on it with their mouse. (Beck et al., 2012)

At the beginning of the summer, our main question was whether or not there is a way to look at a path and determine whether or not that path is of a pilot or a student. While analyzing the data, we took many different approaches such as path comparison methods, entropy, information gain, k-mean clustering, and basic statistical analysis.

Later on in the summer, our focus shifted from analyzing data to building a GUI that psychology researchers will be able to use to do data analysis that is similar to what we did, but with any set of formatted data. It has various path comparison methods programmed into it, and also produces a very large amount of statistical data.

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At the beginning of our project, we had several main areas of concentration. First of all, we found the average, standard deviation, and slope of the following: location of fixations, length of saccades, direction of saccades, angle between saccades, and duration of fixations­. We also used recurrence diagrams that have fixation numbers on the x and y-axis. If a fixation was within a certain numbers of pixels from another fixation, then those coordinates were plotted. There is a line with a slope of 1 going through each diagram, because each fixation is recurrent with itself. With the recurrence diagrams, we calculated recurrence, determinism, laminarity, and center of recurrence mass. Recurrence is essentially a measure of the number of fixations that are recurrent. Determinism looks at the fixations that are recurrent and finds diagonal lines. Essentially, it looks for recurrent sequences. Laminarity is like determinism, but looks at horizontal lines.

After gathering all of this information, we began analyzing entropy and information gain for each characteristic. We wrote functions for entropy and information gain, and then wrote a function to find the maximum information gain for each characteristic. (Mitchell) We did information gain analysis for whether they are a pilot or student, and we also did it for whether they are correct or not. The gains were small and did not seem significant. We also analyzed the time spent on particular trials and overall performance. While analyzing performance, we found that the best pilots had more false negatives that false positives, and the worst pilots were opposite.

One issue that we encountered was that the pilots’ maps were 881X690 pixels, whereas the undergrads’ maps were 740X580 pixels. We were able to successfully scale the pilot data so that it was 740X580 pixels and usable alongside the undergrad data. We also filtered all of the data to enable us to sort by various categories.

To try to classify data, we made a naïve Bayes model and put in the information we had previously made into it. Unfortunately, we did not get very good results out of it. Something else that we did was making a function to find the statistical correlation between whether or not the participant was a pilot and various parameters. The results from analyzing correlation did not produce useful information.

6/25-7/8

After getting mostly empty results, we began looking into new ideas and refined our data. Our goal was to analyze the pilot data alone to try to explain differences within that individual group. We looked at comparing paths of two people looking at the same map. One technique we used was grouping the pilots into thirds and calculating information gain based on whether the pilots were correct or not. Unfortunately, splitting the group into thirds barely affected the information gain numbers. We made tables of maximum gain for all participants, students, pilots, top third pilots, middle third pilots and lower third pilots. After we had fully completed everything with recurrence, we began looking into implementing MultiMatch for path comparison. (Dewhurst et al.)

Along with everything else we were doing, we were also looking into what causes people who are correct to get the right answer. In order to do this, we had to make a function to attempt to evaluate the fit for our statistical models. Unfortunately, we were not able to find a general strategy that would lead to getting a correct answer. During this search, we made heat maps that incorporated fixation location and duration that worked as nice visual aids.

Next, we began looking into ways to quantify clutter. We found a visual clutter program online, but when we finally got it running, it did not work for our maps. After we were unable to get good results from the clutter program from the Internet, we started working on making our own clutter measure. Our first measure converted an image to black and white and found the percentage of black pixels in a region. It was very problematic, because some places that were intuitively of low clutter would have a lot of black. It also had to be adjusted for each trial. Another measure we made used edges. It used the percentage of edges as a measure of clutter. We made a few tables with the information gathered from the second measure and analyzed it, but it turned out to not be very useful.

Another idea that we looked into was defining participant skill with a linear scale based on different weightings of correctness and speed. The results gained from analyzing participants based on skill varied significantly based on how heavily correctness and speed were weighted. Ultimately, we were able to develop a relative ranking based on how many people the pilots beat with respect to correctness and speed. We were quite successful with implementing path comparison methods. We were able to implement multimatch, scanmatch, cross recurrence, fixation maps, and several distance functions.

7/9-7/31

The last part of the summer was spent building a GUI that incorporates many of the data analysis techniques we used. We named our GUI T.E.A.R.S. (Time-intensive Eye-tracking Analysis and Research Software). T.E.A.R.S. allows users to easily upload excel or various types of table data and then in a process that may take up to several hours, it makes a table full of useful statistical information, and formats the data to be ready for further analysis. On the main screen users can load the formatted data and T.E.A.R.S. displays the statistics table, along with some miscellaneous information.

By pressing the Tools button, users may choose from five different options: information gain analysis, group path comparison, pairwise path comparison, fixation plotter, and areas of interest. Information gain analysis allows the user to calculate information gain with respect to groups or with respect to correctness with just the click of a button. Group path comparison allows the user to draw a path and then gives distance information based on ten different types of distance. They include Levenshtein Distance, Scan Match, MultiMatch, and Cross-Recurrence. Before comparing, the user also has the ability to filter which participants are to be compared with the drawn path. Pairwise path comparison allows the user to look at any two participant-trial combinations side by side. It allows users to look at the fixation heat maps, scan paths, and recurrence plots. The fixation plotter allows the user to plot any trial. There is a green dot at the beginning of the path, and a red dot at the end. There is also an option to add duration circles that have radii corresponding to the length of each fixation in time. Area of interest allows the user to select areas of interest in given maps and save them.

Conclusion

Our project’s early failures at finding useful results led to us looking into more ways to analyze our data. We were able to find success by implementing many of these possibly useful techniques in T.E.A.R.S.. With this GUI and properly formatted data, users will be able to reproduce an entire summer’s worth of work in just a few clicks of a button and possibly a few hours of waiting.