# Summary of Project

GPS receivers and RFID technology have made it easier and more common to track the location of automobiles, boats, airplanes, smartphones, equipment, merchandise, and people. There is a growing need for visualization tools to help understand and analyze such data being generated at high rate. One possible visualization method is the 2D visualization which employs 2D maps and markers representing *where* an object has been, but not *when* it was at different locations, in *what* *order* the locations were visited, and *how* *many* *times* each location was visited. An alternative visualization of such movement data uses a 3rd dimension as a time axis. Movements thus become trajectories in a 3D space, with latitude, longitude, and time providing the coordinates of the trajectory. Theoretically, a 3D visualization may allow a user to understand the timing, ordering, and repetitions of events in space-time, and gain an overall understanding of an entire dataset. To better understand the advantages or tradeoffs between 2D and 3D visualizations of movement data, quantitative, experimental evaluations are needed. There is a limited number of prior work that compared 2D and 3D visualizations of movement data, which found mixed results, and which we argue have limited external validity due to the design choices made in the user interfaces that were tested. The ***purpose*** of our study is to compare and evaluate a more realistic implementation of 2D and 3D visualization of movement data through a controlled experiment. We have implemented a prototype that supports both of the visualization methods (i.e. 2D, and 3D) using Java programming language.

***Procedure***: For each of the visualization techniques (2D and 3D), participants will be first presented with the user interface showing the discovery phase allowing them to interact with the prototype during the initial tutorial on various features of the system which will be presented by one of the researchers on site. They will be shown all features of the prototype, in an attempt to get them comfortable with the software. After a few minutes, they will then be presented with the warm-up phase, and asked to answer the 6 questions. During the warmup, users might sometimes be informed about strategies that could help them answer questions more quickly, for example: rotating the 3D view to look at the scene from above to identify certain features in the data. Next, the user will be presented with 3 subsequent trials and asked to answer the 6 questions for each trial. At the start of each trial, the question will initially be displayed at the top of the window with no visualization. After the user reads and understands the question, they can click on the "Start" button in the upper left corner, at which point the visualization will appear and the timer will start. The user can then interact with the visualization (panning, zooming, rotating, dragging the time slider, hitting the "Play" button and adjusting the animation speed, hitting Enter to toggle labels, and hovering over, or clicking, points in the visualization). When the user determines the answer to the question, they will select the answer from the radio buttons in the upper left corner, and click the "Confirm" button, at which point the timer will stop if there was no error. However, if the user's first answer was incorrect, the user can try again, with a limit of 3 attempts before going on to the next trial. Participants may take breaks in between each question.

Each session will take roughly between 40 to 45 minutes. We will gather performance data that includes: time to answer each question, the error rate, and time spent using each of the interaction features in the system listed above. The participants will be required to fill and sign a consent form at the beginning before they start. A questionnaire will also be asked to be filled out by the participants after they completed their session (details for these are included at the following sections).

# Research Instruments

1. ***Desktop Computer:*** The experiment prototype will run on a Dell Optiplex 9010 PC (Personal Computer), with an Intel Core i7-3770 3.4 GHz CPU, 16 GB RAM, an AMD Radeon HD 7570 graphics card, running Microsoft Windows 7 Professional 64 bit, connected to a Dell U2312HM 23 inch monitor. The software prototype will run in full-screen mode, at a 1920x1080 resolution. Participants will operate the prototype with a mouse, and could also hit the Enter key on the keyboard to toggle labels. There are no extra risks associated with using the above instruments other than the known risks associated with normal use of a computer, mouse, and keyboard.
2. ***Questionnaire*** (attached): There will be a questionnaire presented to the participants, which they will be asked to fill out after completing the experiment. The questionnaire which is attached to this application for your review has a free form question for comments or other suggestions from the participants as well as questions on a Likert-scale with responses ranging from 1 (Not preferred/Very difficult) to 5 (Preferred/Very easy).

# Study Subjects

Between 12 to 16 male and/or female general University of Manitoba students will be recruited for this experiment depending on the available resources. Dr. Irani (i.e. the principle investigator) will advertise the experiment on general campus bill boards, including the primary poster boards in the Engineering Complex (see sample poster for advertisement). The participants will be undergraduate and graduate students with experience using a computer, mouse, and keyboard. The participation will be voluntary. They will be able to withdraw at any time during the experiment. They will receive a $15 compensation for participating in the study.

For the data collection, participants will be allotted a unique identification number: their contact information and name will not be associated with the data or the questionnaire in any way.

# Informed Consent

As mentioned above, all participants who participate will complete informed consent form before partaking in the experiment. The form in University of Manitoba letter head is attached.

# Deception

The study will not involve deception

# Feedback/Debriefing

The informed consent form will explain the purpose of the study clearly to the participants before they start. At the end of the experiment, the researcher on site will also go through a debriefing with each participant re-iterating the purpose of the study and explaining the expected results. Any questions or concerns brought up by the participant about the experiment, technology, or research will be addressed and answered by the researcher.

# Risks and Benefits

There are no known risks associated with participating in the study. There are no personal benefits to participants apart from the study incentives detailed bellow under “compensation”. The benefits to the researcher from the study will be data that can be used to analyze and compare performance of 2D versus 3D interactive visualization of spatio-temporal movement data.

# Anonymity and Confidentiality

Participants’ signature on the consent form are the only identifying information that will be collected during the study. All of the identifying information will be kept confidential and will be disassociated from the questionnaire and the rest of the collected data from the experiment by giving each participant a unique code (e.g. P1). The identity information (signature) is collected solely for consent purposes and will be viewable only by the researchers on this project. All consent forms and questionnaires will be stored in a locked file cabinet in Dr. Irani’s office with a lockable door. The identity information and the consent forms will be destroyed as soon as the data analysis and publication are complete. The data will be retained for a period of a maximum one year after publication of the results to which only researchers associated with this study will have access.

# Compensation

Participants will be given a compensation of $15.00 for participating in the experiment. Any participant who decides to quit part way through the experiment will still receive the compensation.

# Dissemination

The result of our study, which has no personal information about the participants, will be submitted for review and publication to academic journals, conferences, and other such publications. It is difficult to estimate when the results will be released due to publication uncertainties. Should participants wish to inquire about academic progress, we provide our contact information to them in the consent form.