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1. Overview of the Project

An Embodied Conversational Agent is a virtual human capable of carrying on a conversation with a person. An Embodied Conversational Agent communicates through language, facial expressions, and hand gestures. NUMACK is the newest Embodied Conversational Agent project. He is a robot designed to give directions around the Evanston campus of Northwestern University using speech and gestures. From the research perspective, the point of the NUMACK project is to study how people use speech, gestures and maps when giving directions, in order to reveal their underlying cognitive representations. This information will then be used to autonomously generate the speech and gestures for NUMACK (Cassell). From the user's point of view, NUMACK will be a useful tool for getting directions around campus.

2. Previous Research

2.1. Rationale

External representations, such as maps, are cognitive tools used to promote memory or thinking. While internal devices are limited by memory and processing, external ones relieve these burdens, allowing for improved memory and information processing. Based on their arrangement of items in space, external representations are effective for making assumptions (Tversky and Lee, 1999). Given that external representations help improve memory by showing spatial locations, including a map with NUMACK would most likely aid users in remembering the route that is being described.

2.2. Content

Landmarks serve a variety of functions in route directions. They are used to signal actions, for example where reorientations occur, to help locate other landmarks, which trigger actions, and to confirm that the person is following the correct route. Landmarks serving these three functions are not necessarily evenly spread out across a particular route. Landmarks tend to occur more frequently at critical nodes. Critical nodes include the beginning and end of a route, places of reorientation, and places where errors or confusion are likely to occur. Also, landmarks can be either two-dimensional, such as streets, boulevards, and squares, or three-dimensional, such as buildings, shops, and statues. While both serve different purposes, three-dimensional landmarks seem to be more popular due to their ease of identification (Michon and Denis, 2001).

Two studies performed by Michon and Denis verify the inclusion of landmarks in route directions. In the first study, participants were shown an unfamiliar route and then asked to generate route directions that would successfully guide someone unfamiliar with the area. The results of this study revealed a major function of landmarks, particularly at critical nodes. In the second study, participants were given a minimal set of navigational instructions and a tape recorder. They were asked to record their difficulties and provide comments and suggestions as they followed the route. The participants reported problems due to the concise directions and most often suggested a solution that involved a three-dimensional landmark (Michon and Denis, 2001).

In a study by Tversky and Lee people were asked to either write directions or draw a map to a nearby restaurant. More than 90% of the maps and directions contained more information than necessary. This information included distances, arrows and landmarks. In another project, participants were given a set of route-finding problems and a toolkit, consisting of words and pictures, to construct the routes using either language or a map. All participants used both the rectangular and round landmarks when constructing a map, showing that people like to include landmarks along the way (Tversky and Lee, 1999). The use of landmarks in both sets of experiments illustrates their equal importance to orientation and actions in a route, thus making a case for their inclusion in the map.

2.3. Representation

Maps are created with a particular goal in mind, generally to communicate a route. This goal determines what information should be kept and what should be eliminated. For this reason, an effective map is simple and clean, only including the most relevant information. A number of techniques, including simplification and distortion, are used to emphasize the most important information and improve the readability of a map. Many elements of the map are simplified. The most basic is omitting information because it is not relevant to the route and gets in the way of the essential information. Also, the shape of roads is simplified to remove extraneous information and allow for more emphasis on the turning points. In addition to simplification, distortion is widely used. A constant scale forces the shorter roads to shrink and possibly disappear. Therefore, an inconsistent scale is used to exaggerate the lengths of shorter roads to ensure they are visible on the map. Although shorter roads are exaggerated, ensuring they remain shorter than the longer roads preserves the overall shape of the route. Angles are also distorted to improve the clarity of turning points (Agrawala and Stolte, 2001; Tversky, 2000). These simplification and distortion methods are important for an effective map.

Maps are generally two-dimensional, although they typically represent worlds that are three-dimensional. There are a number of reasons for this. The most obvious is that it is much easier to portray a two-dimensional space on a two-dimensional surface. Another reason is that people visualize three-dimensional environments as two-dimensional overviews. Furthermore, three-dimensional diagrams are difficult to generate and hard to understand. Lastly, three-dimensional information may be unnecessary because the spatial relation among the roads and buildings is sufficient information (Tversky, 2000). These reasons lead me to believe that a two-dimensional map would be more appropriate and effective for the NUMACK project.

As stated by Habel (2003), a major disadvantage of route maps is that they focus on the spatial environment and not on the sequence of actions being performed. The objects in the map are static and have no orientation. He suggests that a moving-dot map provides the ordered information needed while acquiring the route. Thus, allowing the map to express temporal, as well as spatial information, suggests that including animation along the route would aid in clearly displaying the information on the map.

3. Statement of the Problem

Based on the previous version of NUMACK, there has been no real graphical representation used with NUMACK. MACK used a projector to display a simple path on a paper map. It included minimal spatial and temporal information. From the research presented above, it appears that an external representation would aid in the recollection of the route by the user, making NUMACK more successful in direction giving. This map would incorporate important landmarks and animate the route while NUMACK is explaining it, allowing his directions to be clearer. Illustrating the route in real time will allow the representation of the route to be more visual and interactive, which I hypothesize, will lead to a vast improvement on the previous version of NUMACK.

4. Approach

I decided to use real data of human-human direction giving to determine any helpful information that should be included in a good map. Then I used that information to implement a two-dimensional map using Open Inventor, which includes temporal information as well as displaying spatial locations. I started by creating a small portion of the map, which would then be animated and expanded to the remainder of campus.

4.1. Video Data

Paul Tepper and Stefan Kopp ran an experiment to help gather information such as speech, gestures, and routes for NUMACK. There were 28 sets of people, consisting of one familiar with campus and one unfamiliar with campus. The person familiar with Northwestern was asked to give directions to three different locations on campus, with the intention of the unfamiliar person following the directions to get to these locations. This was all recorded by four video cameras so the data could later be analyzed. The first part of my project consisted of analyzing this data for routes and landmarks.

Approach. Amanda Hosler and I watched the 28 subjects and recorded all of the data related to the route and landmark. We used a print out of the campus map for each subject. The destinations and the route were highlighted, while the objects mentioned along the way were noted with outlining and text. Objects not included on the campus map, such as bike racks and bushes, were referenced in writing, with arrows to their location. After collecting the data from the videos, we made spreadsheets consisting of this data. For each pair of destinations, the total number of routes we had was counted, along with how many different routes were represented. Then we recorded each landmark mentioned and counted the number of times it was referenced.

Data. See Appendix A and B.

Results of Routes. After looking at the data we gathered, we determined that many different routes were taken to get from one point to another. However, with a few exceptions, most of these routes varied only slightly from one another. Since the experiment asked all participants to give directions from Frances Searle to the Allen Center, there is a lot of data for this route. From the 28 participants, 18 gave the exact same route. The next most popular route was given five times, while the remaining five participants gave four different routes. This suggests that there was one clear path between the two buildings that was both popular and straightforward enough to be so common. The last two destinations varied among the participants, giving a total of 16 different options. The paths given for these remaining routes generally varied slightly, i.e. going left or right around a building and going through the library plaza versus going around the library. In addition, people felt comfortable giving directions that diverged from the main roads and led to the small paths through the wooded area of campus. A possible cause for this is because these paths usually had very few turns. A few cases followed Sheridan Road, the main road, instead of through campus; however the majority of these cases went straight to the Arch, which is located on that road.

The subtle differences and divergences from main roads lead me to believe that people look for a route that is popular, simple, and straightforward. A popular path refers to roads and paths that are traveled regularly by many people. This would account for the small differences among the routes because they are typically following the same path. The preference of going through the wooded area would suggest that it is simple and popular.

Results of Landmarks. We noticed some very obvious trends in how people chose the landmarks they mentioned. The first commonly used landmarks were buildings. More often than not, buildings were referenced indirectly as a group. This was most popular when it wasn't necessarily essential information, but was helpful in locating a change in direction or the destination, i.e. "a triangle of buildings" when locating the Rock. However, the most common multiple building reference was to a pair of buildings, i.e. "you'll pass a couple buildings on your left." While many buildings were noted in pairs or groups, others were still mentioned directly by name. This was more common with the large, well-known buildings that were at a critical node or all alone. Buildings were probably common landmarks because they are large, visible and widespread.

Another popular landmark was parking lots. Parking lots were consistently mentioned as landmarks, whether or not the route traveled through them. I believe this is because there are not a large number of parking lots on campus, and they are easily noticed, making them a popular choice for landmarks.

While people tend to include large, visible landmarks, some other popular landmarks included rare objects. These landmarks tend to be noticeable because they are unusual. The first object that was consistently used was a car gate. Other objects frequently used include the lagoon, Deering Field, the Arch, and traffic intersections and stop signs. The use of these objects suggests that people also like to choose landmarks that are not widespread and would only be found when traveling on the correct route.

The location of landmarks also revealed some trends. There are a few points where landmarks are more habitually cited. The data we used supported Michon and Denis about where landmarks are most often used. These points include the beginning of the route, the destination, turning points, and places where confusion may occur. The beginning and ending points of a route tend to include landmarks for the purpose of identifying the surroundings, to more easily identify the specific destination. In addition, when a turn occurs, there is always something mentioned, commonly a building, parking lot, or sign. Places of confusion, such as the many paths in the wooded area, also included supplementary information, generally a landmark or something specific about the path.

Difficulties. Some of the problems run into during this part of the research were mostly minute details. The first difficulty was deciding the best way to record the data. We started out writing everything down, but this was tedious and hard to follow. We quickly realized this was a poor choice and chose to follow the method described above. A surprising problem area was that I was confused by some of the directions. It was very difficult to follow what they were talking about, even with a campus map in front of me.

Another problem area was the routes chosen for the participants. Since there were 28 total participating dyads covering many routes, it made it difficult to analyze the routes described. There were very few routes given between destinations, with the exception of Frances Searle to the Allen Center, so the sample size for each route was 3.5 routes on average. With such a small number of routes, it makes it difficult to determine any similarities or general trends between the routes.

Furthermore, this study was not performed for the purpose of determining routes and landmarks. The direction-giving participant was allowed to become familiar with the route by visiting the destinations beforehand. The intention was to study the gestures given by the participants, and had nothing to do with the routes given or landmarks mentioned. Therefore, there were many routes chosen for variety in the gestures, instead of a few routes, with the purpose of being compared. Consequently, this is not the best data that could have been used for the analysis of routes and landmarks, making it difficult to draw these types of conclusions.

Summary. Many useful ideas were revealed in the video data, including typical landmarks and paths people chose. People pointed out both popular and rare objects when citing landmarks. The location of these landmarks showed another tendency of the video subjects. The areas with the highest number of landmarks were the beginning, the end, turning points, and places of confusion. There were also patterns in the routes people chose; most of the participants described similar paths.

These results are very important for the rest of the project. The information we discovered about landmarks will be useful for my portion of the project, and for others. It will be used when I decide which landmarks should be included on the map, and also, when deciding what additional information NUMACK should mention while explaining the route. The ideas we gained from the routes people chose will be helpful in determining which route NUMACK will use, and thus which route will be animated on the map.

4.2. First Iteration

Based on what I discovered from the previous section, I knew the map would need to include certain characteristics, such as all buildings, parking lots, roads, the lagoon, the Arch, and the Rock. These are the main landmarks throughout campus that needed to be included in the map.

The first iteration involved making the preliminary map, which was a simple, static two-dimensional map. Amanda and I decided this version would focus on the route from Frances Searle to the Allen Center, so only this section of campus was included.

Approach. The first step in this part of the project was deciding what to write the code in. After discussing this with Marc Flury and Stefan Kopp, I decided to use Open Inventor. Open Inventor builds on OpenGL and the code is at a higher level. Open Inventor is a three-dimensional platform, but could easily be used to implement a two-dimensional project. I was already familiar with OpenGL and wanted to learn something new, so I decided to use Open Inventor. The next step was to learn how to use it. I spent some time reading through *The Inventor Mentor* and looking at the examples. Then I wrote some code of my own, playing around with different shapes and curves until I was fairly comfortable with it.

I decided to write a few functions for the basic shapes being used in the map. I had functions to draw a rectangular building, a road, parking lot, and circular shape. These functions took in the values that would allow the object to be transformed, allowing for scaling, translation, and rotation. This created a simple way to draw the objects instead of many lines of repetitious code for each object. A couple buildings required more detail and are comprised of a few different rectangles.

The level of detail I chose to include is rather simple. I decided that the buildings should generally be as simple as possible, except when a building cannot be accurately represented with a rectangle. This was the case with a few buildings because of the odd shape of them and the nearby roads and parking lots. A rectangular shape for the building would result in the distortion of the map taking away from the simplification of it. Thus the representation of the buildings is more realistic than simply a rectangle. I also chose to simplify the shapes and curves of the roads. The simplification still shows the turning points, which is the important information here. This decision was based on my prior research about the representation of maps. Another design decision I made was to include all of the buildings. Although some research suggested this information was extraneous, I felt it was important to accurately represent the campus. These buildings may not be essential for a particular route, but they are not interfering with the important data. Also, confusion may occur if a space appears to be wide open when in reality there is a large building there. Thus, the landmarks chosen in the first part of the research will stand out in the animated route.

Data. See appendix C for image of first iteration.

Difficulties. I had some problems early on learning Open Inventor. My first problem was that nothing I drew was showing up on the screen. I went back to the book and looked at some of the examples. This helped me realize that my problem was the order of the code I was writing. Another large problem I ran into was drawing circular landmarks. I was using a cylinder with a very small height to represent a circle, however, it needed to be rotated. I had a difficult time trying to rotate it because the angle of rotation is specified using radians instead of degrees. OpenGL uses degrees and so I assumed Open Inventor also used degrees. A third problem I experienced was in scaling my objects to the correct size. I accidentally scaled the z direction by a factor of 0 instead of 1, which was causing the object to appear very dark, but still visible. I first thought it was a lighting problem, but Stefan helped me discover this problem. Other than these few problems, the first iteration went well.

4.3. Animation

The next step in my project was to animate the map. The animation involved taking in a route as input and drawing it on the map. The drawn route consists of the route being drawn on the map and the landmarks standing out in some way, whether it is through highlighting or circling.

Approach. The main idea was to have a second thread in the Open Inventor code constantly checking for a new route. Once a route was found, the parser would read in the information and create RouteSegments. The RouteSegments would contain the appropriate information to draw that portion of the route. This includes the translation, scaling, and rotation information as well as the time for the segment to be drawn on the map. These RouteSegments would be used to create the route, and the current time would be reset. After the route is created, the time for the RouteSegments is compared to the current time. When the time is greater than the current time, the segment is drawn on the map. These segments would remain on the map for a specified length of time after the entire route is drawn and then would disappear.

Difficulties. This stage of the project was definitely the most difficult. I had a very hard time working on this part for a number of reasons. The first was that it has been over a year since writing C++ code. I was having trouble remembering how to do certain things like using threads and parsing a file. The Internet was helpful for the most part with these problems. Another issue I was experiencing was getting the files to work with the Open Inventor code. The most difficult challenge and most probable cause for little progress in this part was that most of the people in the lab were gone during this time. I got to the point where I was getting many errors that I didn't understand, and it was difficult to proceed from this point because I had to ask for help via email.

5. Conclusions and Future Work

5.1. Conclusions

Based on the video data, there were some very obvious trends in how people chose the landmarks they mentioned. The first commonly used landmarks were buildings, more specifically, groups of buildings. Other popular landmarks were parking lots and other rare objects. Another noticeable trend was in the location of the chosen landmarks. The portions of the route most populated with landmarks include the starting point, the destination, turning points, and places where confusion may occur. From the routes people chose, we observed some similar tendencies. People like to choose popular and simple paths. Also, they aren't afraid to diverge from main roads, when there is a more straightforward way to get there.

Although my project was not completed, some aspects were successful. We were able to determine many characteristics about routes and landmarks from the video data. Not only was this an important part of my project, but it is crucial to the NUMACK project in general because his purpose is to communicate routes using these landmarks. So this information will be very helpful in the future of the project. Also, I was able to create the preliminary map for NUMACK and get started on the animation portion.

5.2. Future Work

Since I was unable to finish my project, the obvious future work is to complete it. The animation portion of the project needs to be finished so that it can draw the route and also highlight the landmarks in some way. Once this is complete, the second iteration of the map should be completed. This iteration involves expanding the map to cover the rest of campus. In order to do this I would add the new destinations and landmarks to the map as well as any additional roads or paths needed. After this was completed, the routes and landmarks would need to be determined from the first part of my research. This data is important for the animation of routes taking place through the rest of campus.

Another possibility for the future is to produce the map and route on the fly. This means there would be a database containing all of the information needed to draw the buildings, roads, parking lots, etc. Such data would include the dimensions, location, and orientation of the objects. The input for this system would be the route and objects involved in the route. This input would be used to extract the necessary information from the database and produce the map and route while NUMACK is explaining it. So, the map shown would only be the part of campus relevant to the particular route, instead of the whole campus. This would probably be a better option because only the necessary information would be included. The user would not be confused by extraneous buildings and roads.

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Appendix

A. Route and Landmark information from Frances Searle to Allen Center

Route	Landmark	No. times mentioned	Percentage
	Frances Searle to Allen		
Path 1	Do Not Enter sign	1	5.56%
left around Searle to p1 to p2	Roundabout	6	33.33%
count = 18	Alleyway/cul-de-sac	9	50.00%
	Bushes	4	22.22%
	Garbage cans	5	27.78%
	Cook	10	55.56%
	Pancoe	1	5.56%
	Grass patch / path	9	50.00%
	Parking lot 1	18	100.00%
	Field	2	11.11%
	Road	7	38.89%
	SPAC	1	5.56%
	Construction	7	38.89%
	Lampposts	1	5.56%
	Parking lot 2	17	94.44%
Path 2	Do Not Enter sign	5	100.00%
DNE sign to overpasses to Hogan	Overpass	4	80.00%
cut through to p2	Buildings	1	20.00%
count = 5	Tech	1	20.00%
	Hogan	4	80.00%
	Pathway	4	80.00%
	Building with big glass windows	1	20.00%
	Construction	1	20.00%
	Parking lot 2	5	100.00%
Path 3	Garbage cans	1	100.00%
through Cook, between Hogan	Cook	1	100.00%
and Pancoe to p2	Pancoe	1	100.00%
count = 1	Parking lot 2	1	100.00%
Path 4	Stop sign 1	2	100.00%
right around Searle to p1 to p2	Stop sign 2	2	100.00%
count = 2	Parking lot 1	2	100.00%
	Buildings on right	1	50.00%
	Parking lot 2	2	100.00%
Path 5	Cook	1	100.00%
through Cook to p1 to p2	Parking lot 1	1	100.00%
count = 1	Buildings on right	1	100.00%
	Construction	1	100.00%
	Parking lot 2	1	100.00%

Path 6	Do Not Enter sign	1	100.00%
DNE sign to overpasses to brick	Alleyway	1	100.00%
path through grassy area to p2	Garbage cans	1	100.00%
count = 1	Brick walkway	1	100.00%
	Grassy area between 2 buildings	1	100.00%

B. Landmark information for all routes

Frances Searle to Allen count = 28 number of different paths = 6		
Landmark	**No. times mentioned**	**Percentage**
Do Not Enter sign	3	10.71%
Roundabout	6	21.43%
Alleyway/cul-de-sac	10	35.71%
Bushes	4	14.29%
Garbage cans	7	25.00%
Cook	13	46.43%
Pancoe	2	7.14%
Grass patch/path	9	32.14%
Parking lot 1	22	78.57%
Field	2	7.14%
Road	7	25.00%
SPAC	1	3.57%
Construction	8	28.57%
Lampposts	1	3.57%
Parking lot 2	28	100.00%
Overpass	4	14.29%
Buildings	1	3.57%
Tech	1	3.57%
Hogan	4	14.29%
Pathway	4	14.29%
Big glass windows building	1	3.57%
Construction	1	3.57%
Stop sign 1	2	7.14%
Stop sign 2	2	7.14%
Buildings on right	2	7.14%
Brick walkway	1	3.57%
Grassy area between 2 buildings	1	3.57%

Allen to Dearborn count = 4 number of different paths = 1		
Landmark	**No. times mentioned**	**Percentage**
Parking lot 2	3	75.00%
Grassy area	1	25.00%
Dome of observatory	4	100.00%
Brick pathway	2	50.00%

Allen to Deering count = 4 number of different paths = 3		
Landmark	**No. times mentioned**	**Percentage**
Parking lot 2	4	100.00%
Buildings-Annenberg/Nanofab.	2	50.00%
Grassy area	2	50.00%
Parking lot 3	1	25.00%
Kellogg	2	50.00%
Deering field	2	50.00%
Seminary	2	50.00%
Swift	2	50.00%
Central utility plant	2	50.00%
Stairs to plaza of library	1	25.00%
Lake	1	25.00%
Car/toll gate	1	25.00%
Library	1	25.00%

Allen to Rock count = 3 number of different paths = 2		
Landmark	**No. times mentioned**	**Percentage**
Parking lot 2	3	100.00%
Pedestrian crossing	1	33.33%
Deering	1	33.33%
Deering field	2	66.67%
Courtyard	3	100.00%
Stop sign	1	33.33%
Lake	2	66.67%
Parking lot 3	1	33.33%
Swift	1	33.33%
Kellogg	1	33.33%
Library	2	66.67%
Bridge	1	33.33%
Car/toll gate	1	33.33%
Norris	1	33.33%
Triangle of buildings	2	66.67%

Allen to University count = 8 number of different paths = 6		
Landmark	**No. times mentioned**	**Percentage**
Parking lot 2	8	100.00%
Observatory	1	12.50%
Grassy area	1	12.50%
Annenberg	1	12.50%
4-way stop	4	50.00%
High walls - Swift/Central UP	1	12.50%
Bridge	1	12.50%
Central utility plant	1	12.50%
Swift	2	25.00%
Parking lot 3	3	37.50%
Lake	5	62.50%
Car/toll gate	2	25.00%
Stairs to library courtyard	1	12.50%
Garage doors to library docking	1	12.50%
Library	5	62.50%
Courtyard	2	25.00%
Kresge	4	50.00%
Rock	3	37.50%
Harris	1	12.50%
Annie May Swift	5	62.50%
Kellogg	1	12.50%
Triangle of buildings	1	12.50%
Sheridan	1	12.50%
Stop light	1	12.50%
Deering field	2	25.00%
Small arch	1	12.50%
Quad area	1	12.50%
Deering	1	12.50%
Norris	1	12.50%

Allen to Norris count = 7 number of different paths = 2		
Landmark	**No. times mentioned**	**Percentage**
Parking lot 2	6	85.71%
Lake	7	100.00%
Stairs to Norris	3	42.86%
Bridge	3	42.86%
Library	5	71.43%
Stop sign	2	28.57%
Car/toll gate	1	14.29%
Annenberg	1	14.29%

Allen to Pick-Staiger count = 2 number of different paths = 1		
Landmark	**No. times mentioned**	**Percentage**
Parking lot 2	2	100.00%
Central utility plant	1	50.00%
Lake	2	100.00%
Norris	2	100.00%
Library	2	100.00%
Car/toll gate	2	100.00%
Stairs	2	100.00%
Two square monument	1	50.00%

Dearborn to Arch count = 4 number of different paths = 2		
Landmark	**No. times mentioned**	**Percentage**
Brick pathway	2	50.00%
Parking lot 3	4	100.00%
Sheridan	4	100.00%
3 - way intersection	4	100.00%
Deering field	1	25.00%
Millar	2	50.00%
Group of buildings	1	25.00%
Foster - stop light	1	25.00%
Emerson - no light	1	25.00%

University to Norris count = 1 number of different paths = 1		
Landmark	**No. times mentioned**	**Percentage**
Courtyard in library	1	100.00%
Library	1	100.00%
Annie May Swift	1	100.00%

University to Arch count = 5 number of different paths = 2		
Landmark	**No. times mentioned**	**Percentage**
Rock	3	60.00%
3 - way intersection	4	80.00%
Plaza/courtyard	2	40.00%
Bed sheets in trees	1	20.00%
Triangle of buildings	2	40.00%
Small arch	1	20.00%

University to Pick-Staiger count = 2 number of different paths = 2		
Landmark	**No. times mentioned**	**Percentage**
Arch	1	50.00%
Millar	1	50.00%
Student residences	1	50.00%
Northwestern sign	1	50.00%
Parking garage	1	50.00%
Rock	1	50.00%
Harris	1	50.00%
Kresge	1	50.00%
Annie May Swift	1	50.00%
Quad area	1	50.00%
Theatre center	1	50.00%
Stairs	1	50.00%

Rock to Millar count = 3 Number of different paths = 1		
Landmark	**No. times mentioned**	**Percentage**
Arch	3	100.00%
Sheridan	3	100.00%
3 - way intersection	2	66.67%
Bed sheets on path	1	33.33%

Pick-Staiger to Rock count = 2 number of different paths = 1		
Landmark	**No. times mentioned**	**Percentage**
Annie May Swift	2	100.00%
Kresge	2	100.00%
University	2	100.00%
Harris	1	50.00%
Clearing	2	100.00%

Norris to Deering count = 2 number of different paths = 1		
Landmark	**No. times mentioned**	**Percentage**
Stairs	2	100.00%
Library	2	100.00%
Courtyard	2	100.00%
Café	1	50.00%
Revolving doors	1	50.00%

Norris to Arch count = 5 number of different paths = 3		
Landmark	**No. times mentioned**	**Percentage**
Library	5	100.00%
Rock	2	40.00%
Path w/flyers	1	20.00%
Parking lot 4 & parking garage	3	60.00%
Kresge	2	40.00%
Annie May Swift	1	20.00%
University	2	40.00%
Courtyard	1	20.00%
Bushes	1	20.00%
Theatre center	2	40.00%
Student residences	1	20.00%
Sheridan	4	80.00%
Bed sheets in trees	1	20.00%
3 - way intersection	3	60.00%
Kellogg	1	20.00%
Car/toll gate	1	20.00%

Deering to Pick-Staiger count = 1 number of different paths = 1		
Landmark	**No. times mentioned**	**Percentage**
Library	1	100.00%
Car/toll gate	1	100.00%
Two square monument	1	100.00%
Stairs	1	100.00%

Deering to Rock count = 3 number of different paths = 2		
Landmark	**No. times mentioned**	**Percentage**
Annie May Swift	1	33.33%
Kresge	3	100.00%
University	3	100.00%
Deering field	2	66.67%
Harris	2	66.67%
Bike racks/bushes	1	33.33%

C. First Iteration of Map