A SOFTWARE TOOL FOR RAPID ACQUISTION OF STREETWISE GEO-REFERENCED MAPS

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Abstract

RapGeoRef, a software tool for rapid acquistion of streetwise geo-referenced maps, is presented.

Introduction

One problem with many GPS systems is that they do not have streetwise knowledge that is most useful to the visually impaired traveler. While Google maps [1] is a step in the right direction, they do not have a universal resolution level with some areas covered in much more detail than others. In addition, there are many areas of the world, especially in developing countries, where such maps are not available. Another problem with Google maps is precision. Many GPS coordinates on Google maps, while acceptable for car drivers or sighted travelers, are not acceptable for visually impaired travelers.

RapGeoRef (rapid geo-reference) is a tool that helps a lay care giver, e.g. a relative, a friend, an O&M instructor, with no knowledge of GIS to geo-reference quickly a specific area with an inexpensive GPS sensor and a digital compass. The acquired database can later be shared with other visually impaired travelers through a variety of means, e.g. blogs, wikepedias, web GIS services, and user-updatable GPS navigation packages, e.g. software packages developed by the Sendero Group, LLC [2].

Localization Model

The acquired database is expected to be used at run-time for localization and orientation on demand, not for minute-by-minute tracking of the navigator's position. The navigator is equipped with a GPS receiver, a digital compass, and a cellular phone. In the experiment, the receiver and the compass were packaged in one wrist-placed unit connected to a cellular phone with BlueTooth shown in Figure 1. As more and more cellphones come equipped with GPS chips, it is reasonable to suggest that a GPS-enabled cellphone would be a sufficient hardware platform for using the acquired databases.

The navigator points the device in a specific direction. The software that runs on the device collects the GPS and compass fixes and describes, via synthetic speech, that landmarks in front of the person in a specific cone of vision, e.g. 30 degrees and within 50 meters away from the person.

Let the current true position of the user be (x, y). Vincenty's formula is appled to the GPS fix and the GPS coordinates of some known location in the environment (z, w) to obtain a distance d and heading phi of the current position with respect to (z, w). Then x and y are computed as x = z+d*cos(phi) and y = w+d*sin(phi). The current orientation (theta) is found from the digital compass.

Each landmark in the database is represented as a polygon with sides extending approximately 50 feet from the true edges of the landmark. If (x, y) lies within a specific polygon, the difference between theta and the angle made by the current point to the center of the polygon. If the difference is less than a threshold, the phrase "Landmark X is in front of you" is communicated to the navigator. If the distance is greater than the threshold, "You are near landmark X but not facing it" is communicated to the user. If (x, y) is not in any polygons, "no landmarks around you" is communicated.

Rapid Acquisition of Geo-Referenced Maps

It should be apparent from the assumed localization model described above that the use of it requires an accurate streetwise geo-referenced map of the environment. As we said in the introduction section, such maps are not readily available for many areas. RapGeoRef was developed as a tool for non-professionals to do such streetwise geo-referencing. The tool's GUI uses bitmap aerial images of the environments, e.g. images from Google Earth would do. The geo-referencing process consists of selecting several collection points for each bitmap image, collecting GPS fixes on each collection point, specifying the needed landmarks as polygons, and labeling the landmarks with descriptive strings. If the environment is too big to be represented with one map, the environment is divided into submaps. Each submap has a reference point associated with it. The reference point is the center of the map. At run time, the localization software computes the distance from the current location to the reference point to choose that submap whose reference point is closest to the current point. The polygons, collection points the reference point are shown on a submap of the Utah State University campus in Figure 2.

Experiments

A evaluation study of RapGeoRef was performed on the USU campus with four students. The participants were told about the purpose of the tool and shown a demo. They were then asked to construct a geo-referenced database for an area of the USU campus. Upon completion, they were given the NASA TLX questionnaire [3] to assess the subjective workload. A detailed analysis of the experiment is given in [4]. All participants were able to complete the task in one day. The analysis of the NASA TLX questionnaire revealed that the temporal demand was much more prominent to the participants than either mental or physical effort.

Acknowledgments

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References

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[2] Accessible Localization and Navigation, http://www.senderogroup.com/index.htm.

[3] Hart, S. and Staveland, L. Development of NASA-TLX: results of empirical and theoretical research. In Hancock, P., Meshkati, N. (Eds.) Human mental overload, pp. 139-183. North Holland, 1988.

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Figures

Figure 1. Bluetooth enabled GPS device.

Image description: A user is shown wearing the bluetooth enabled GPS device on his hand.

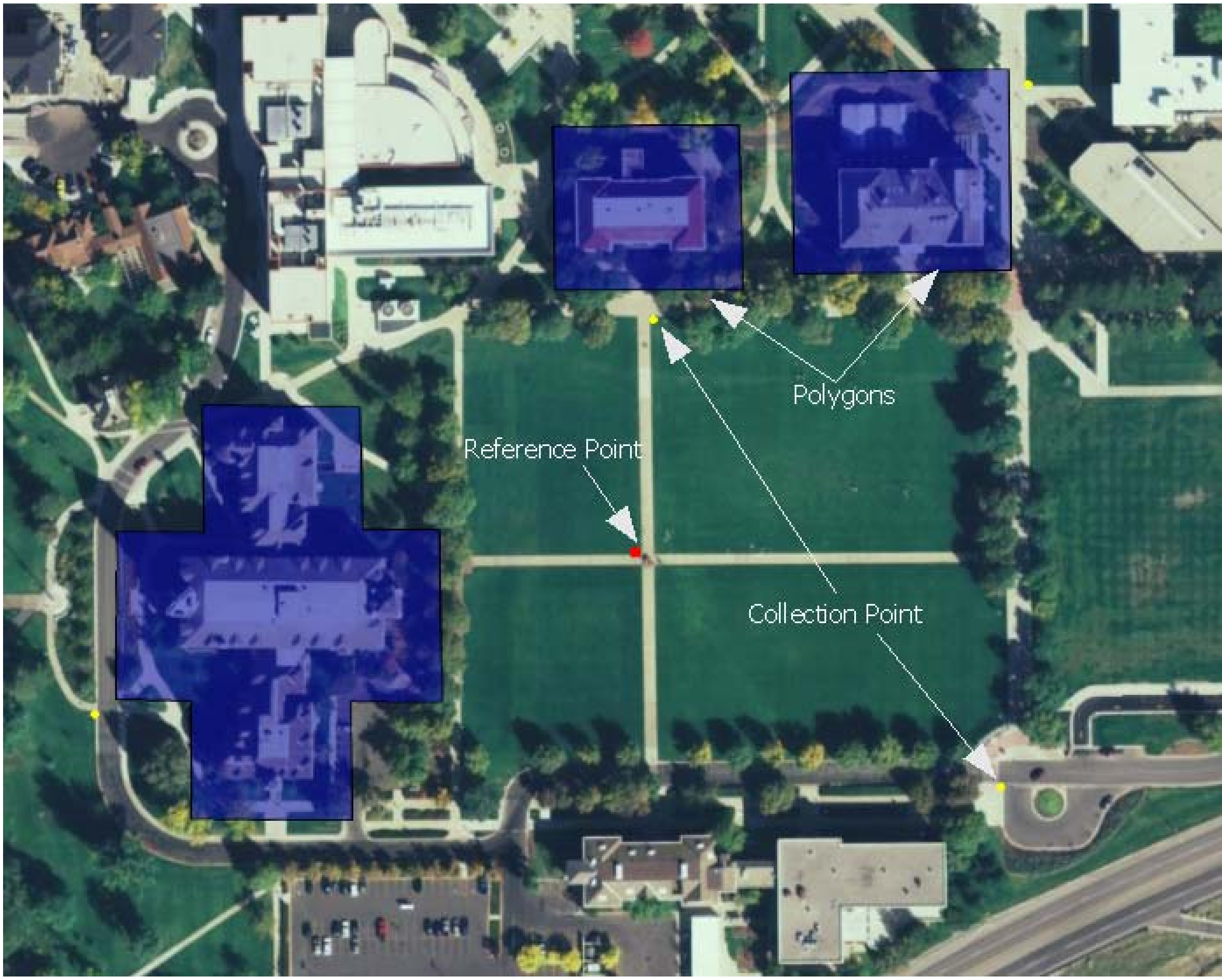

Figure 2. A submap of the USU campus showing the polygons, collection points and the reference point.

Image description: This image shows a submap of the USU campus. Polygons are drawn around the buildings. Collection points are shown at various places on the map and the reference point is shown in the center of the map.