**3d Visualization Construction from Topographical Maps**
**EE 368 Project Proposal**

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**Motivation:**

When examining maps (such as those provided by the USGS), one is often interested in altitude of the terrain shown. On standard maps, this is often represented with labeled contour lines. However, it may be the case that it is difficult to actually visualize how the terrain looks in 3d just based on the 2d projection. Therefore it is proposed that a system is created that will analyze an image of a map, especially pertaining to the contour lines, and reconstruct the 3d model from what is found. Beyond visualization for human consumption, digitizing elevation characteristics could prove useful for other GIS applications.

**Technical Considerations:**

A brief survey of existing research into this topic indicates that there is already a fair amount of existing work on the problem. For example both [2] and [3] provide proposed methods that have a fair level of agreement between processes.

The majority of topographical maps today have different map features keyed to different colors. For the sake of discussion, it shall be said that on a particular map, the contours are brown in color. The trivial solution to extracting the contours from a map would then be to segment the image by color such that only brown pixels are extracted. A model would then be fairly easy to construct by just performing some contour tracing algorithm on the segmented image. It should be noted line thinning is recommend to aid with processing. The line thinning can be done with something as simple as a morphological erosion, although this may not be ideal since it may cause discontinuities.

However, the naive method proposed above obviously falls short for situations where the segmented image has gaps in contours, as may arise when a contour is labeled with its elevation. Therefore some curve reconstruction algorithm is needed to complete the broken contours. This operation seemed to be the one that was most different among all read sources, and it is the intent of this project to examine a number of curve reconstruction algorithms to characterize which has the highest success rate.

Various other considerations include how to interpolate between neighboring contours and, perhaps more importantly, how to account for regions where contour lines may be indistinguishable from each other, as can happen in areas of rapid elevation change such as cliffs. More thought needs to be put into this problem, but an initial idea is to modify a contour tracing algorithm to count how many contours enter and leave an indistinguishable region and use that knowledge when constructing a model.

**Plan of Attack and Goals:**

The baseline goal of this project is to have a tool that recognize and reconstruct broken contour lines and construct a 3d visualization of the surface. The baseline goal would not account for some of the harder complications such as contour overlapping. Extension goals would be to be able to construct

a visualization for any map with a high rate of success, requiring accounting for the more edge condition behavior. Another extension is to examine different curve reconstruction algorithms to see which yield the best success rates. The envisioned plan of attack would be as follows:

1. Implement model construction for an image that is only unbroken contour lines (no extraction needed).
2. Implement contour extraction from general topographic maps, as well as other processing, for the unbroken contour case.
3. Implement a curve reconstruction algorithm (TBD) such that maps that yield broken contours after segmentation can be processed.
4. Extension: implement edge condition code, such as overlapping contours.
5. Extension: implement different curve reconstruction algorithms, and perhaps some ML to choose which algorithm to use if it is found that there is a correlation between map characteristics and algorithm success rate.

**Miscellaneous:**

I will not be using a DROID camera.

**References:**


1. Amin, Tushar J., and Rangachar Kasturi. "Map data processing: recognition of lines and symbols." Optical engineering 26.4 (1987): 264354-264354.
2. Salvatore, Spinello, and Pascal Guitton. “Contour line recognition from scanned topographic maps.” Journal of WSCG 12.1-3 (2004).
3. San, Loh Mun, et al. "Extracting contour lines from scanned topographic maps." Computer Graphics, Imaging and Visualization, 2004. CGIV 2004. Proceedings. International Conference on. IEEE, 2004.
4. Amenta, Nina, Marshall Bern, and David Eppstein. "The crust and the β-skeleton: Combinatorial curve reconstruction." Graphical models and image processing 60.2 (1998): 125-135.