David Kleszyk
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Homework 2
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Floor Plan Generation via Analysis of Panoramic Photography

The proliferation of digital cameras on mobile devices enables a wide range of applications that use visual data. One area of focus is the stitching of multiple photographs together into a panorama that can represent a much wider angle than possible with a single lens[1]. Typically, these applications focus on the aesthetics of photo stitching and are used for artistic purposes. However, there are many uses for extremely wide angle photography that are currently unexplored. One of these avenues is using information about the physical information of the camera to estimate the sizes of objects in the photograph. What I propose is: given a panoramic photograph of a room, and given some reference object in the photograph (e.g. the height of the room), compute the dimensions of the room by identifying boundaries with the walls, floor, and ceiling, and giving this information to the users.
A product that could extrapolate room dimensions from a set of photographs stitched together into a panorama would be useful to a relatively wide consumer market. Although such an application would most likely not be accurate enough for professional construction and remodeling, for homeowners looking to get approximate dimensions of a room for the purpose of arranging furniture or sizing appliances. Professionals may also use this application to get an idea of the size of a room for calculating estimated materials needed and costs.

Technically, this application would require feature extraction, and line recognition. The main challenges would be differentiating objects in the room from the room boundaries. This could be alleviated partially by focusing on the ceiling boundary, which will usually have fewer obstructions than the floor boundaries. Once the room boundaries have been identified, the distance between the ceiling and the floor can be used as a point of reference for the size of objects in the photograph. A number of possible measures could determine the distance from the ceiling to the floor: enabling the user to enter the value explicitly, using alternative ranging sensors such as ultrasonic sensors, using an estimate based upon standard sizes of doors and windows, and using a fixed default value for all rooms. Of these, the most convenient for this product will most likely be referencing the standard sizes of doors to provide an estimate of room size; however, this will require further image processing in order to differentiate and recognize the doorways.

Another piece of information that would be necessary is the relative positions from which the photos were taken. It is important because the perspective will change if the user moves around the room to take pictures, and this would alter the estimated size for the room boundaries. The user's location could be determined by integrating accelerometer data taken from the mobile device. Gyroscopic data could be used to determine camera orientation. These pieces of data would greatly improve the stitching functionality of the application, as it would give the program an approximate location for each image in the overall map.

This application would be developed on both the Android platform and the iOS platform, with a primary focus on the Android platform due to its lower boundaries to market entry. The goal would be to provide

a standalone application that enables users to take multiple photographs of a room, then outputs an approximate floor plan based upon these images. The application would also enable this image to be sent via email. A possible extension to the product would be an online floor plan editor that would allow users to position furniture and other objects on a floor plan that was uploaded via the mobile application. This would be a product developed independently of the mobile application. The market segment is homeowners in the age ranges 20-40, with an emphasis on less technical users who would be less likely to perform room measurements themselves. Key goals are a simplistic user interface and accurate feature recognition and floor plan generation.

The major stakeholders for this product are the user, client, and designer. In this case, the users would be owners of smart phones. The market segment would be homeowners in the age ranges 20-40. Requirements the users would put on the product would be: 1) product can size a room up to 20 ft by 20 ft in size with accuracy of +/- 2 in 2) product will be accessible to 85% of users without need of reading a manual or instructions 3) product can stitch photos together with an angular displacement of up to 5 deg and overlap of up to 5% 4) generate the floor plan of a room with a worst case time of at most two minutes and an average time of at most twenty seconds.

The client and designer in this case are the group of developers. The mobile application market allows for designers to self-publish applications without need for a middle man in deployment. The client would require: 1) the product has a ROI of at least 5% 2) the product has a break-even timeframe of less than or equal to 12 months 4) the product does not require significant investment after the initial development. The designer would require: 1) the product is easily maintainable and extensible 2) a clear definition of what needs are to be met by this product 2) a clear timeframe during which to develop the product 3) licensing of any intellectual property needed to develop the product.

For the iPhone application market, the average sales within a yearly time frame was over 10,000 sales for the typical application, with an average sale price of approximately $5 [2]. Apple takes a 30% cut of revenue, leaving revenue of $3.50 per application sold. This product should be worth at least $35,000 within its first 12 months on the market. Assuming a development time of 6 months by a team of three engineers working quarter days (with a yearly salary of $80,000), the costs for development will be $30,000. This means that the product has a positive net present value within its first year on the market.

The estimate for development time is based upon three workers putting in approximately 720 man-hours. This would be split approximately between approximately 180 man-hours for product planning, 180 man-hours for primary development, and 360 man-hours for testing and reiterations. Assuming that each semester is 14 weeks long, and assuming that product development would occur over the course of two semesters, to develop this product successfully would require each worker putting in approximately nine hours a week. Nine hours a week is a reasonable estimate for development time: class time will consist of roughly six hours each week, leaving three hours a week for individual work.

Depending on the technology developed for this product, a secondary market could exist for intellectual property developed for the photographic manipulation and analysis that form the core of the product. Although image recognition algorithms have been well documented and well-developed, applying them to a panoramic image to judge the size of objects in the room is something that may not be registered. This method would have applications beyond this product’s scope including mobile robotics platforms, and defense and security.

Skills needed for this product's success would be 1) knowledge of the application platforms for which the product is being developed; this may be either Android or iOS 2) knowledge of the hardware contained in the devices on which this product will run 3) a basic understanding of optics to be able to formulate equations to correct for lens distortion and to be able to compare objects in photographs using knowledge such as camera aperture and focal length 4) familiarity with image processing algorithms to stitch photographs together into a panoramic photograph 5) familiarity with image processing algorithms to identify wall, ceiling, and floor boundaries in the panoramic photograph 6) familiarity with user-interface coding to be able to develop an effective and simple product for the user to experience.

Strengths for this product include 1) the low initial investment required to enter the market 2) the effort already invested in documentation for the iOS and Android platforms provides a solid foundation for a product 3) homeownership, and thus renovation, is an extremely large market in the United States, even with the recent economic down turn 4) the low overhead cost in running a small development team for a very focused product 5) the short time taken to reach break-even 6) the small development team will allow for nimble changes to the product.

Weaknesses for this product include 1) the lack of control over the distribution channels for the product 2) the small nature of the team precludes typical large-scale product testing and marketing 3) the developers on the team will most likely be relatively inexperienced in mobile application development and in image processing 4) the small development team will make it difficult to effectively generate a large and diverse number of concepts and possible solutions.

Opportunities for this product include 1) the secondary market for intellectual property has the potential to be lucrative 2) retail home improvement chains such as Home Depot and Lowe's may express interest in acquiring this product if it can reliably determine room size and proves popular to customers 3) the potential for expansion exists into more general home improvement software if brand name is successfully developed.

Threats for this product include 1) there is a possibility that the accuracy of the calculations will not be within tolerable bounds for estimating room size 2) although no similar products could be found currently on the market, it may be that the intellectual property has already been developed and registered 3) the market estimation for the product is greatly over estimated and sales are less than expected 4) the product is dependent on hardware in a rapidly developing market 5) external time demands made by other classes may interfere with the development time necessary for this product.

This product has great potential to be very successful. The large size of the homeowner market, coupled with the proliferation of camera-enabled mobile devices and the desire of users to reduce the amount of physical work required to complete tasks, provides a large selling point for this product. If image stitching and recognition can be successfully applied to images taken from a mobile device, then this product is essentially guaranteed to work; given the advances in image processing that have occurred over the past decade, this requirement is very likely to be met.

[1] http://wmpoweruser.com/pano-panoramic-photo-stitching-app-now-available-in-windows-phone-marketplace/
[2] http://techcrunch.com/2010/05/16/iphone-app-sales-exposed/
[3] http://cool-hubber.hubpages.com/hub/make-money-with-iphone