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Application for Automatic Measuring of Objects in Augmented Reality

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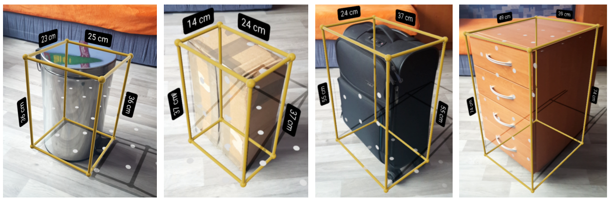

Abstract
This article describes the technology for automatic measurement of overall dimensions of a generic object using a commercially available mobile phone. The user only has to go around the measured object and scan it by the mobile phone's camera. The measurement uses computer vision algorithms for scene reconstruction in order to obtain the object's point cloud. This paper proposes algorithms for processing the point cloud and for estimating the dimensions of the object. It focuses on collecting and filtering points where the biggest challenge is to recognize and separate points belonging to the measured object from the rest. Proposed algorithms were tested on an implemented Android application using ARCore technology. The result of measurement on a cuboid object had the error about 1 cm. An object with other shapes achieves measurement error from 3 to 5 cm. The measurement error was independent on object size. This implies that the algorithm is more accurate for larger objects with the shape approaching cuboid.

Keywords: Augmented reality — Measurement — Android — ARCore — Point Cloud

Supplementary Material: Demonstration Video — Downloadable Application

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1. Introduction

Sometimes is necessary to measure an object but no ruler is available. If approximate dimensions are sufficient, it is possible to compare the object with an object of known size and estimate them. This article describes a technology which can automatically measure an object using a commercially available mobile phone. Typical usage is when the user has to decide if the measured object fits in a required place. For example, when he needs to know if the package fits in the trunk of the car. Or to verify that the size of hand luggage meets the airline limits. The goal is that the proposed technology will be more accurate than human estimation.

The solved problem is specifically placing a minimal three-dimensional bounding box around the interested object. This problem is simplified to a placing bounding box aligned with a horizontal plane which represents the floor or another pad.

Currently, existing mobile applications provide object size detection from the camera image. Their principle is firstly a plane detection in the image. It is possible to determine the distance of two points on these planes if we know their position. A user of this type of application have to select two or more points on the detected planes and then the application can estimate distances between them. Example of this principle is in the figure 1.

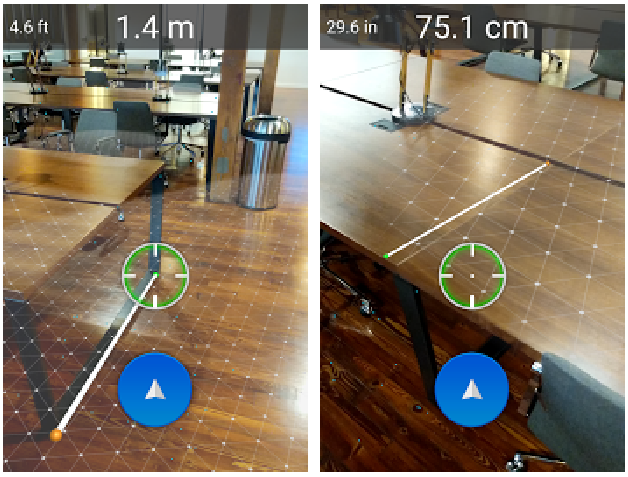

Figure 1. Application *Air Measure* for measuring in augmented reality. Image shows placing two points onto a detected plane and an estimated distance between them.

This article describes a different approach which can make this process more automated. Proposed measure process requires to collect a point cloud belonging to a measured object. Points should evenly cover most of the object's area. This resulting point cloud is filtered and simplified to achieve a noise elimination. Remaining points are used for construction minimal bounding box. Size of the box is presented as overall dimensions of the measured object.

2. Environment recognition

The environment recognition is a computer vision problem whose solution is important for many technologies. One of them is augmented reality (AR) where is necessary to align a physical and virtual environment. According to Azuma [1], this alignment is one of the main properties of AR.

Augmented reality on mobile phones is relatively specific. It can use only hardware which most mobile phones typically has. This includes a camera, acceleration sensor, gyroscope or light sensor. This restriction complicates environment recognition. Is necessary to use computer vision algorithms for processing a two-dimensional image from the camera. This problem is called *Simultaneous localization and mapping* (SLAM). In this case, is the mobile phone an agent which is localized in a physical environment and simultaneously maps them. Summary of this problem and possible solutions can be found in the article by Cadena et al. [2].

3. Measure process proposal

This section describes a propose for automatic measurement of overall dimensions. Decomposition of the

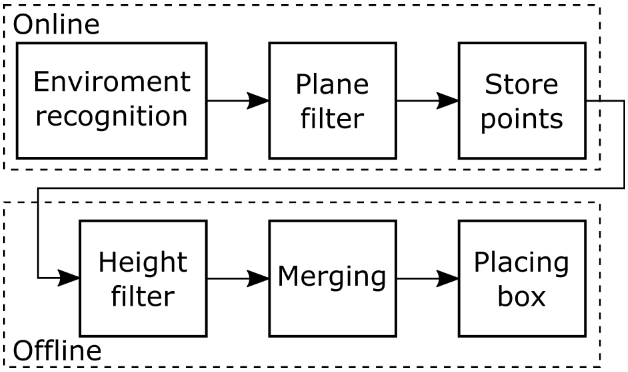

Figure 2. Visualization of proposed measuring algorithm. Online part is performed for each frame and offline only once when is object size necessary.

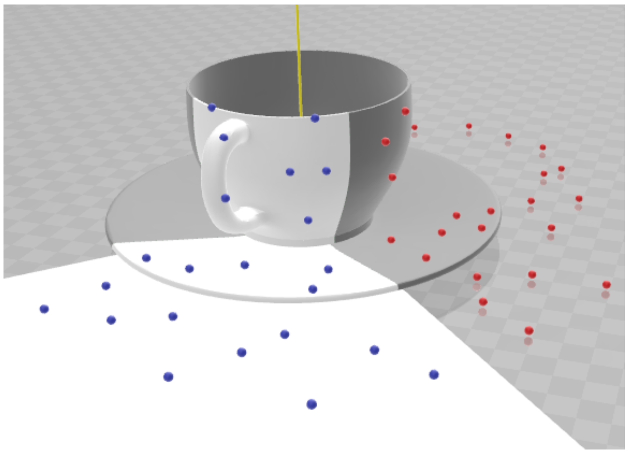

Figure 3. Visualization of point cloud filtering. Yellow line is axis of symmetry. White color indicates slice near to the user. Blue points are collected and red discarded.

algorithm is illustrated in figure 2 and individual parts will be described below. This article assumes an existing technology for an environment recognition (first block in figure 2) which can detect points and planes of physical environment. A set of all detected points is called a point cloud. Products of the environment recognition are typically delivered in frames.

It is necessary to determine which points are part of the measured object. Figure 3 visualizes a proposed principal. It is required to know the approximate axis of symmetry of the object. Then is possible to take only points lying in a slice near to the user. Other points are discarded. This filter corresponds with the block *Plane filter* in figure 2.

Full object can be scanned by continuous saving of these points (block *Store points* in figure 2). Except a position is for each point saved weight. Points have initial weight set to 1. In case when are saved same point multiple times is weight incremented (environment recognition algorithms typically returns points with unique id).

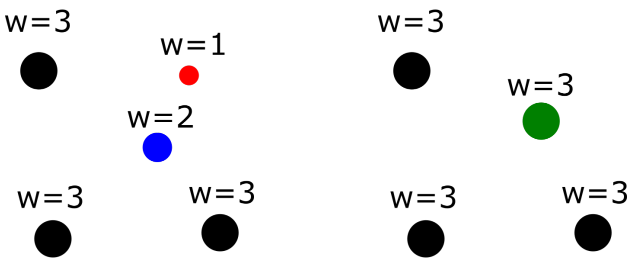

Figure 4. Example for merging points. Left image shows point with minimal weight (red) which should be merged with nearest (blue) point. On right image is the resulting point (green).

Previous parts are performed for each frame. Following algorithms are used for collected points typically once. Collected point cloud contains points of the floor and other noise. Experimentally was discovered that the bottom half of the point cloud can be discarded to eliminate the floor. This is performed in block *Height filter* in figure 2. For noise reduction was proposed a merging of points (block *Merging*). This process is visualized in the figure 4. There must be specified value W_{min} which is target minimal weight. Merging is performed until exists any point with a weight less than W_{min}. The point with minimal weight is merged with the nearest point. An output of them is a single point where the position is weighted average and final weight is the sum of input points weights.

From the reduced points is possible to estimate the overall size of the object. As the overall size is, in this case, meant the size of a minimal three-dimensional bounding box. Cubic-time algorithm for computing minimal bounding box in 3d was published by Joseph O'Rourke in 1985 [3]. Assume that the measured object lies on a horizontal pad and position of the pad is known. Then it is possible to swap 3d bounding box problem to a counting of 2d bounding box. Points should be transformed from 3d to 2d points which are lying on the horizontal pad. Counted 2d bounding box must be transformed back to 3d. This operations are done in block *Placing box*.

4. Implementation and experiments

The implemented application is for Android operating system with technology ARCore[1]. It is a library which allows work with augmented reality developed by Google. This technology was used for environment understanding. It exposes to the programmer a plane detection and point cloud. As a programming language was selected Kotlin.

[1]Available at: https://developers.google.com/ar/

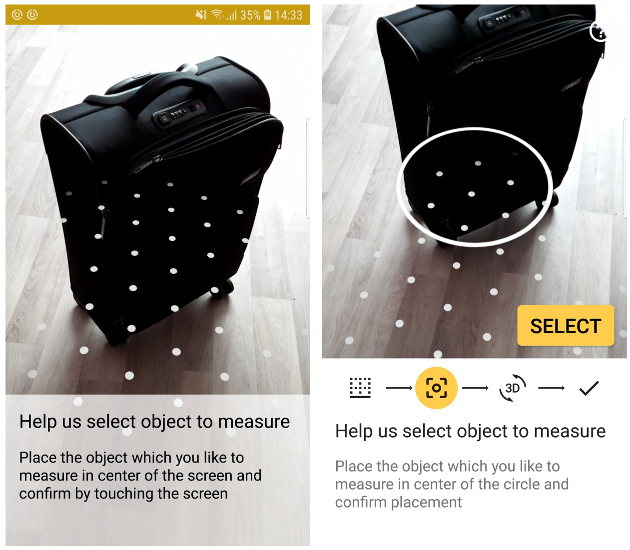

Figure 5. Design of implemented application *AR measure*. First design on the left side and final design on the right.

For accuracy assessment was used comparison with known size objects. Accuracy was tested already during development. Proposed algorithms were iteratively modified especially threshold values and other constants. For example value of W_{min} was experimentally set to 3. Figure 6 shows comparison between real and measured dimensions.

From the comparison is evident the greatest measure error on a height dimension. This is due to the inaccurate selection of a detected horizontal pad. ARCore detects multiple horizontal planes, which are gradually refined. A current algorithm for the plane selection takes the biggest one. This selection is possible to improve and the result should be the refinement of the height measurement.

Design of the user interface is based on a proposed measure process. The measurement is divided into 4 phases. Firstly is necessary to detect a horizontal plane on which is the measured object lying. In next step should the user select center of the object. In the third phase are collected points. The user has to go around the object and capture them from all sides. The fourth phase only shows the result of the measure. Figure 5 shows evolution of the design. On the left image is first design where are phases distinguished only by texts. Thanks to feedback from users were phases better visualized by icons and animations. This is visible on the right image of figure 5.

5. Conclusions

This paper proposed a different way how to develop applications for measuring in the augmented reality.

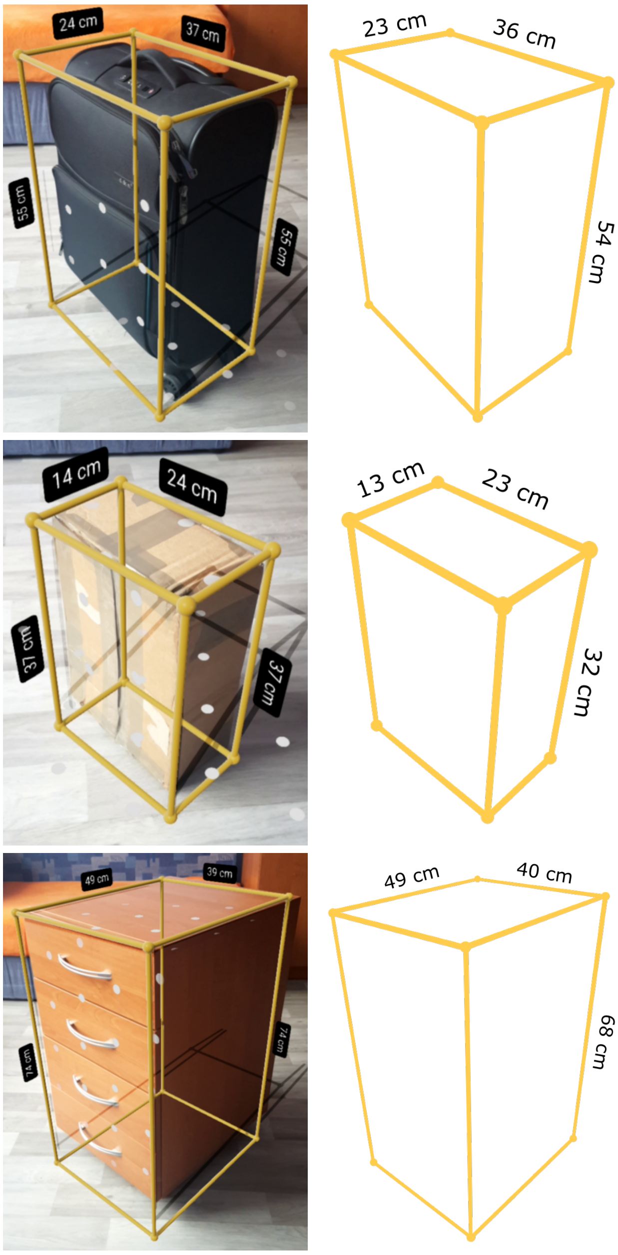

Figure 6. Comparison between dimensions measured by the application (left) and real dimensions (right).

Described algorithms were practically checked. They were implemented in Android application but is possible to take over them to different platforms. Experimentally was discovered that error of measure for cuboid objects was about 1cm. The height of objects showed greater error from 3cm to 5cm.

Plan for a future is to extract the source code of the described algorithms and publish them as an open source library. There are still some phases which can be more automated. One of them is a selection of a measured object which is currently done manually by the user. Also, it's possible to improve measuring of height. Current measure error is caused by inaccurate detection of the floor.

Acknowledgements

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