# REAL WORLD SCALE IDENTIFICATION THROUGH IMAGE PROCESSING

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Dissertation submitted in partial fulfillment of the requirements for the B.Sc. Special Honors Degree in Information Technology.

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# DECLARATION

I declare that this is my own work and this dissertation[1] does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Mr. Udara Samaratunge

# ABSTRACT

Customers who purchase furniture from dealer have to wait till the furniture arrives at the location in order to check if that products matches with the expectation they had when purchasing it. Customer get dissatisfy with the purchased product due to the colors, design or scale not suiting the location where they want it to be placed. Increasingly advancing technology of marker-less augmented reality is trend that could have a large impact on the furniture industry. High end smart phones drives applications to use technologies like machine vision.

When projecting 3D furniture it may scaled irrelevantly according to the environment which lead user to a simulation gap. Procure the length units that a pixel represents through the system must be addressed. Lack of visual perception in smartphone camera causes detecting objects present in the environment and scaling them. Using image processing techniques like line detection which then develop to a contour is a fine mechanism to object detection. Algorithm can be developed to calculate the height of detected object by making use of angle of view and the actual distance to the detected object which derives length units that a pixel represents.

Filling the above mentioned simulation gap provide users to get a real experience through virtual furniture improving client interaction and faster decisions to make a purchase. Reduction of wrong customized orders and cut down of operational costs and time also a support the large impact on the furniture industry.


**Keywords:** Marker-less Augmented Reality, Image processing, Scale

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Finally, I would like to thank my parents for their support and encouragement throughout my studies.

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# LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| AR | Augmented Reality |
| SLAM | Simultaneous Localization and Mapping |
| PTAM | Parallel Tracking and Mapping |
| DTAM | Depth Tracking and Mapping |
| SDK | Software Development Kit |
| IDE | Integrated Development Environment |
| API | Application Programming Interface |
| RAM | Random Access Memory |
| GHz | Giga-Hertz |

# 1 INTRODUCTION

## 1.1 Background Context

Today, most of the world's population owns a mobile device, driving consumption of more digital media than ever before. Considering digital market path to purchase is anything but linear which consumers expect seamless experiences across the physical and digital. Augmented Reality leverages the benefits of traditional and digital marketing in a whole new channel, making offline marketing interactive, engaging, and measurable. Through AR marketers in a digital world can obtain

- Reduction of wrong customized orders
- Cut down of operational costs and time
- Standardized placement of orders and instant price calculation
- Easy realization of complex product configurations
- Improved client interaction and faster decisions
- Realization of up-selling opportunities

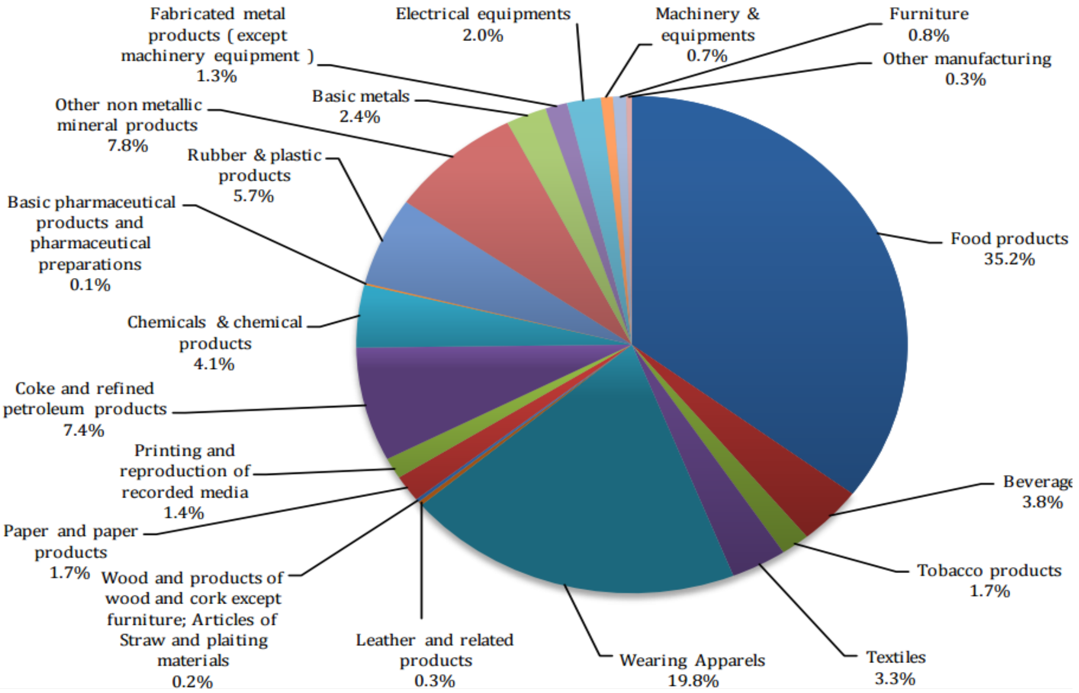


Figure 1.1.1 - Composition of the Index of Industrial Production- Department of Census and Statistics Sri Lanka

According to the statistics provided in annual survey of industries [Figure 1] which is carried out by the department of census and statics in Sri Lanka, furniture production industry is a stable industry having weightage of 0.8/100 from total productions within a year which is more than the production of machineries, electronics and leather related products in Sri Lanka. With the help of new marketing strategies like augmented reality, the furniture industry can be improved causing the maximum customer satisfaction.

### 1.1.1 Literature survey

Augmented Reality aims at simplifying the user’s life by bringing virtual information to his immediate surroundings. According to the Sisi Zlatanovaa, George Sitholeb, Masafumi Nakagawac and Qing Zhud [1] considering new methods of augmentation it can be made new visualizing technologies causing more information transfer to user. “Markless Furniture” the developed product eases the purchasing and demonstrating stages of furniture by projecting 3D furniture on to user’s mobile phone camera view. User need to interact with immediate surroundings through camera of the mobile phone which 3D Furniture (virtual information) will be projected. Mobile camera act as a platform between virtual and real world. A goal of this product is to simulate the experience of a real furniture trough 3D model so that user can proceed with purchasing. User will be driven to his right choice by this approach. In case of simulation projecting of 3D model should be done according to correct scale or else it may drive user to mistakes. This report narrates how “Markless Furniture” projects 3D models in accurate scale to camera view.

AR is a new and rapidly advancing technology that will give enormous possibilities to improve the experience through online shopping [4]. The fact that the use of smartphones and tablets has exploded the last couple of years is crucial and makes AR more practical as a potential shopping tool. A Study in Visioning & Adopting Augmented Reality within the Swedish Furniture Industry shows that most of the people within different furniture firms in Sweden believed that AR is not a threat to the physical store, but a possible enhancement of it [5].

Figure 1.1.2 - AR-Visualization of Furniture with Smartphones & Tablets. (Courtesy of IKEA)

According to Elizabeth and Gustavo [5] main challenges of AR are realism of the rendered 3D objects mixed with the real world due to surrounding real world the light cannot be fully controlled or predicted, the 3D object is projected according a lighting model that might not match the one that actually exists in the real world causing user to feel 3D object is yet a virtual object. Another challenge is in what scale factor the 3d object must be projected according end-user's viewpoint position and the size of surrounding real objects.

When projecting 3D objects to end-user's viewpoint (device Screen) it is to be consider Camera calibration and the acquisition of Euclidean 3D measurements. Kiriakos, Kutulakos and their team [6] described a new approach to video based augmented reality that avoids both requirements. Instead of using any metric information about the calibration parameters of the camera or the 3D locations and dimensions of the environment described method uses the ability to track across frames at least four fiducial points that are specified by the user during system initialization and whose world coordinates are unknown. Observing the projection of all points in a set of four or more noncoplanar 3D points can be computed as a linear combination of the projections of just four of the points they are tracking regions and color fiducial points at frame rate and representing virtual objects in a non-Euclidean, affine frame of reference that allows their projection to be computed as a linear combination of the projection of the fiducial points.

Considering estimation of scale camera feed include far objects and near objects in order to process the scale so it is need to identified and process the scale. Alper Yilmaz describes two methods to track objects in a video captured using mobile camera. [7] The first tracking method is a patch based. It uses color and local intensity deviation to represent the objects during tracking. For each object detected in the first frame, kernel density estimate of the color and local intensity deviation is computed. The second tracking method tracks the contours of the objects detected in the first frame. Implemented contour tracker uses color and texture to model the objects and background. In addition, conditioning the tracking of the object contour on previous contours results in shape priors which increase the robustness of tracking during partial or full occlusions.

A robust and powerful representation is required for object detection to work. Objects are characterized by their appearance, especially their texture, and by the shape of their contours. [8] Joseph and Björn presented an effective and computationally efficient representation of contours and junctions that accurately localizes and describes the local shape of contours. Contours are description of local curvature and junctions with a non-parametric distribution over oriented bars at interest points. In addition to detecting objects, they showed that presented approach can find the most relevant contours and junctions in each object hypothesis.

Figure 1.1.3- Contour Detection

Morphological image processing describes a range of image processing techniques that deal with the shape of features in an image. Morphological operations are typically applied to remove imperfections introduced during segmentation. Mathematical morphology (set Theory) can be used as a tool of extracting image components that are useful in the representation and description of region shape such as boundaries. Erosion and the Dilation are fundamental functions of morphological operations [9]. Erosion is an operation which takes a normal image A, and a so called structure element, S. A structure element is a just small mini-image, typically something like a 3×3 set of black pixels.

- Erosion

$$A \ominus S = \left\{(x,y) \mid S_{(x,y)} \subset A\right\}$$

Where

$$S_{(x,y)} = \{(x+i, y+j) \mid (i,j) \in S\}$$

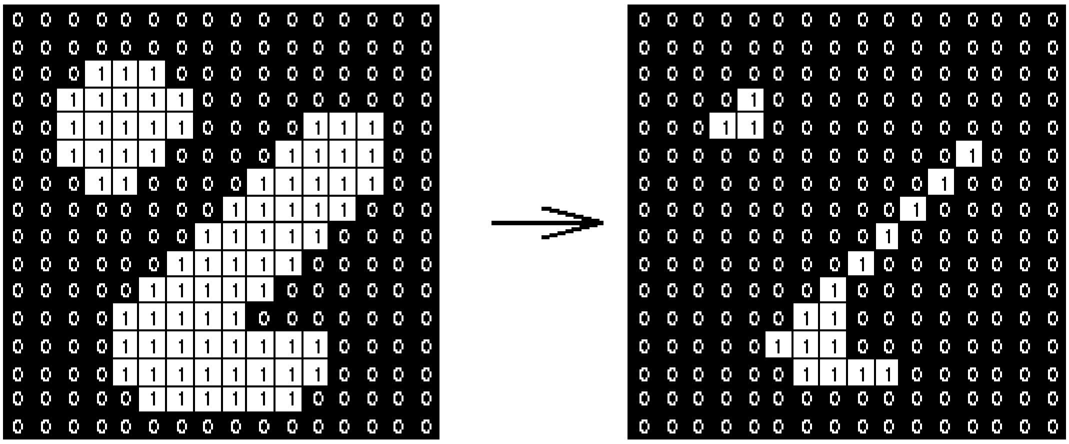


Figure 1.1.4- Erosion: a 3×3 square structuring element (www.cs.princeton.edu/~pshilane/class/mosaic/).

- Dilation

$$A \oplus S = (A^c \ominus S)^c$$

C. Holzmann and M. Hochgatterer [2] found a way to measure dimensions of objects

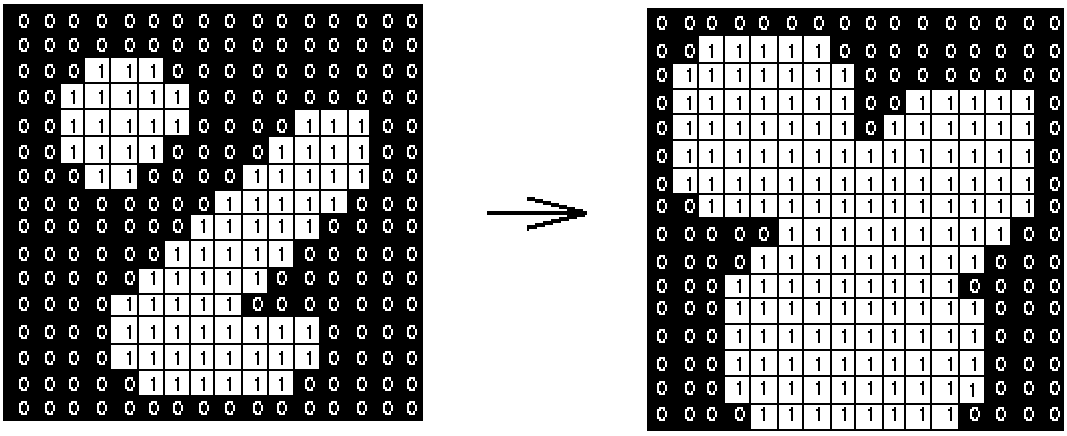


Figure 1.1.5 - Dilation: a 3×3 square structuring element (www.cs.princeton.edu/~pshilane/class/mosaic/).

using mobile camera by determining the distance between the camera positions. They observed that lighting conditions and unintentional device rotations influenced the results. A “baseline” is used to estimate which is based on the accelerometer reading in combination with the gyroscope data and increasing the baseline leads to high accurate results. The device must contain both gyroscope and accelerometer in order to perfume.

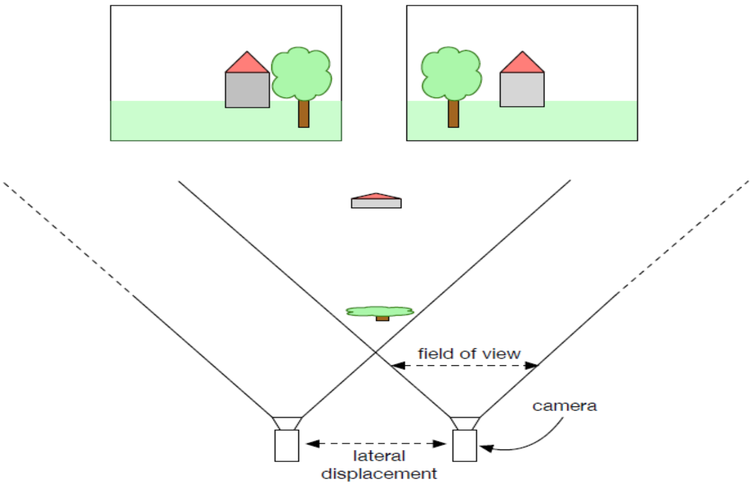



Figure 1.1.6- Two images recorded from a laterally displaced camera. The displacement of the objects provides relative depth information

Mahdi Momeni-K., Sotirios Ch. Diamantas, Fabio Ruggiero and Bruno Siciliano [3] estimated the height of an object by getting use of height, pitch angle of the camera (respect to the ground) and the focal length of the camera (using a single camera).

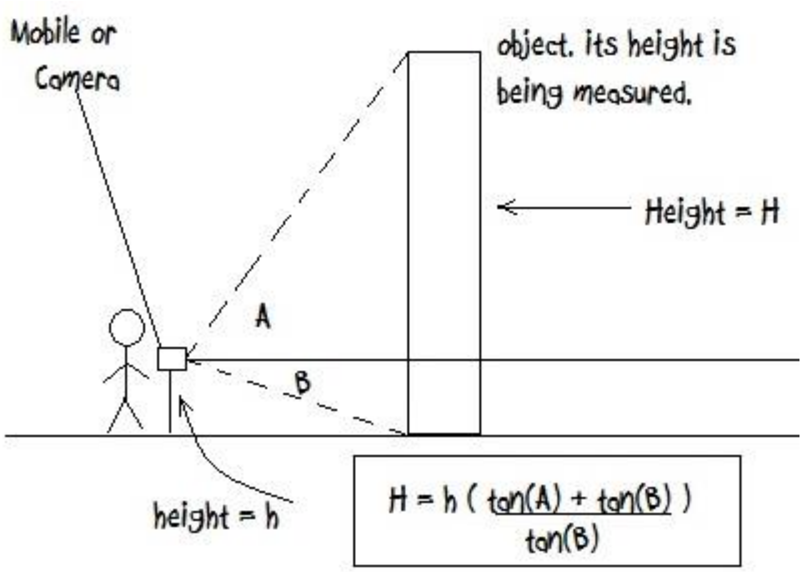



Figure 1.1.7- estimating the height of an object by getting use of height, pitch angle of the camera

Existing products with related to the furniture industry allowing customer to augment virtual furniture can be identified in the global market. Following is a comparison between each product that involve in furniture industry.

- Augment [10]

Northern Lighting specializes in the design and manufacturing of premium lighting. The company uses Augment to link its 2D print materials such as catalogues to its virtual product showroom where its entire furniture collection is available in 3D augmented reality.

After downloading the free Augment app, customers scan Northern Lighting's brochures to try all of the lamps in scale in augmented reality from the comfort of their own homes before buying. Northern Lighting's entire augmented product line is accessible to its clients from anywhere at any time. While viewing a product in augmented reality, customers also have direct access Northern Lighting's mobile shop via Augment's app.

Northern Lighting sees a great opportunity in using Augment. The company's customers are more engaged when using the augmented product catalogue compared to a traditional print one. And more, it has been able to reduce its number of physical samples and costs.

- VIUTEK-uDecore [11]

uDecore is our customizable 3D Room Planner utilizing a patent pending Augmented Reality technology for iOS devices. It can visualize multiple photorealistic 3D items to create stunning room planning configurations for kitchens, bathrooms and living rooms.

uDecore can support hundreds of furniture models that can be customized and placed in a virtual 3D room planner. Users can take snapshots of their designs and share them with family and friends. The furniture models can be permanently stored in iOS devices or downloaded from a server. In addition to a comprehensive 3D Room Planner users can make use of a photo of their room or visualize 3D furniture items using augmented reality with the camera live preview mode.

- Sayduck [12]

Sayduck decided to enable virtual showrooms, making it possible for consumers to "try before they buy".

Initially, Sayduck investigated a web-based WebGL approach but quickly realized its limits to achieving their vision. As a next step, Sayduck tested different mobile augmented reality platforms. They selected the Vuforia™ mobile vision platform because of its ease of use, quality and seamless integration with Unity.

Using Vuforia, Sayduck developed a series of product visualization apps enabling consumers to see all kinds of products - from sofas to sinks - within their homes or offices, thereby helping them to make better-informed purchasing decisions, as well as allowing products to be purchased directly from within the app. High-end furniture manufacturers and retailers immediately grasped the value of having such virtual showroom apps. Not only would they alleviate the burden of stocking large, expensive items in every color and material, they would make shopping more personal and productive.

- Augmented furniture [13]

Once you have found the furniture that fits better in your room you can start configure it choosing your favorite setup, color, material or texture or you can combine it with other objects to complete the décor of the interior. You can then save your configured object in your wish list and share it with your friends. Take a screenshot of your furnished interior and send it off via Email, Pinterest, Twitter or Facebook and collect comments and reviews from your friends. They will help you choose the right product for your needs.

Press the “I Want It” button and complete the purchase of the object of your desires by choosing between buying InStore (with Voucher) or Online (with Promotional Code). If you choose to buy InStore the app will issue a Discount Voucher in pdf with specified the characteristics of the selected object, a map with the nearest shops where to buy and the special discount reserved for you. If you choose to buy Online the app will send you an email with a Promotional Code to be used on the manufacturers’ website to complete the purchase.

## 1.2 Research gap

“Markless Furniture” will focus on the furniture industry and innovational approach in getting use for possible future market changes due to technological innovations like E- Commerce which is a trend in almost every business and it has exploded the last decade which is a fact for the furniture industry. This in-store shopping culture has not substantially changed because customers really cannot assess the furniture by viewing pictures of them. Looking at the pictures of product online and its information is not enough to convince customers to make a purchase unless they wanted to feel and hold the product. Hence increasingly advancing technology of Augmented reality could have a large impact on the furniture industry. Examine through applications that already in the market which most of them are marker based making users to struggle with markers (An image or pattern of the real world pre-stored in a database). Implemented system uses marker less approach and including real time furniture suggestions, ability of controlling app through voice and calibrating with environment by estimating scale which the virtual object should be projected in order to simulate the real experience of the furniture.

In order to convince customers to make a purchase using AR they need to get the feel and hold experience through the application by projecting the virtual objects in correct scale. If a virtual furniture is in a irrelevant scale respect to the projected real environment it will not be the actual feel and hold experience to the user. Considering the above mentioned facts it is clear that there is a clear research gap in this domain that need to be addressed and filled.

## 1.3 Research Problem

The Implemented system utilizes a technology call Augmented Reality (henceforth referred to as “AR”) uses a mobile device’s camera to superimpose a computer-generated image or 3 dimensional (henceforth referred to as “3D”) model on to a user’s view of the real world. The traditional Augmented Reality tools which were used until now relied upon a pre-defied marker (A image or pattern in the real world) on to which the computer-generated object can be placed. The Implemented system will be utilizing the AR technology but will move a step forward in the direct marker-less tracking. This as the name in itself defines will not use pre-defied marker for tracking, instead this technology analyzes the user’s surrounding and define track points which can then be used to lock 3D models into place. This method will provide user with greater mobility and allow him/her to view and customize the placed object in any direction and distance without always having to focus on a marker. The Implemented mobile application will be utilizing Marker-less AR for furniture placement, customization and interaction.

The main augmented reality solution for placing 3D furniture in runtime defined real world environments. The solution needs to be mark-less, stable, supportive wide-range of devices, user-friendly, secure and consistent. The current augmented reality solutions do not provide means in which to properly utilize marker-less augmentation. This research based project tries to identify methodologies to provide marker-less augmented reality on a mobile platform and provide a solution where customers can view and customize 3D furniture on their desired location and identify whether the relevant real furniture might actually suit the location.

## 1.4 Research Objectives

### 1.4.1 General Objectives

- Give customers with a mobile application that provide 3D models of furniture which can be placed in their home to identify where it suits them before purchasing actual product.
- Provide a means to customize the furniture with the respective customizations provided by the dealer.
- Voice recognition feature to allow customer the ease of customizing 3D models placed in the scene.
- Provide a suggestions feature that identify the real world location's main color and provide furniture suggestion to suit it.

### 1.4.2 Specific Objectives

- Scan the real world environment and provide data necessary for marker-less AR.
- Identification of objects in the environment in order to calibrate with virtual objects.
- Grant mechanism to change tracking strength and change the distance to the detected object to make user to move freely.
- Provide algorithms to calculate detected objects real scales and change the scale of virtual objects accordingly.

# 2 METHODOLOGY

Estimating scales of "Markless Furniture" was conducted focusing on following milestones.

- Arranging the environment for developing.
- Getting the camera feed inside the product ready to process.
- Isolating the objects of present in a video frame.
- Implementing a mechanism to estimate one Baseline which will use to calculate the scales.
- Implementing an algorithm to calculate scales.

## 2.1 Approach

After analyzing requirement an agile methodology was inherited as Software Development Life Cycle (SDLC). Since there were many milestones throughout the project it is important to make prioritize work items and finish them at the relevant milestone.

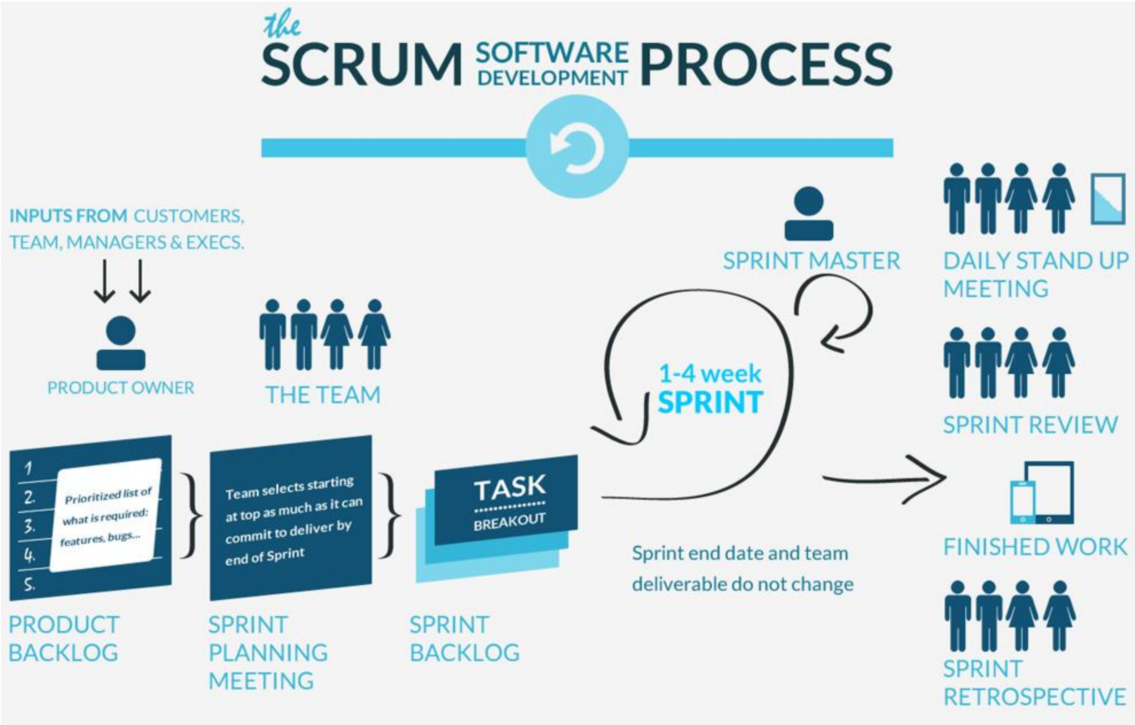



Figure 2.1.1 - The SCRUM agile development methodology

SCRUM creates self-organizing teams who learn to manage themselves efficiently, as team members soon realize accountability through the actions of selecting and reviewing their own work. SCRUM promotes self-management, improved communication, improved quality and a controlled and iterative approach to product releases.

## 2.2 Requirement Gathering

As the target users of the "Markless Furniture" are mobility impaired, we need to develop a high user friendly, efficient system. Therefore, we need to identify the main required functionalities by users, how the systems carried out and what are the draw backs of those systems. Is required a possible methodology to develop a solution for the current problems. Requirements could be gathered by,

- By studying on researches about Scale identification and Augmented reality that carried out in the world to come up with a new best solution.
- Go through books and research articles regarding scale identification or estimation.
- Reading online materials such as tutorials, research papers, web articles, programming code and e-books and building sample applications and test.
- Visit some furniture stores in Sri Lanka and get the information about how they convince customers to make a purchase and take a feedback by proposing the system.

## 2.3 Methodology

Considering the IDEs for developing AR applications Android Studio and Unity 3D play major roles in industry. Apart from developing normal mobile apps it is needed to take in account that "Markless Furniture" working with 3D models of furniture. Using a IDE which support many AR frameworks may lead to ease of alterations in future modifications. Due to unity is open source and cross platform almost every major AR frameworks has Unity integrations, causing to get a huge developer base. Qualcomm Vuforia, Wikitude, Kudan are some of major players in AR industry which has unity integrations. According to the facts that mentioned it was better to use Unity 3D as the IDE for "Markless Furniture".

OpenCVForUnity is used to retrieve machine vision.


Figure 2.3.1 - Smart phone camera vs DSLR
source - http://www.gizmodo.com.au/

The market of mobile devices is still growing. The number and quality of embedded sensors increase with the versatility and performance of such devices increase. This leads to the opportunity of using mobile devices for more specific tasks like image processing. In order to maintain proper image quality following obstacles have to be taken into account.

- The image sensors are low-cost and prone to a certain amount of image noise
- Mobile device is handheld and not fixed in its position which leads to motion blur artifacts.
- Mobile devices are used in constantly changing environments implying that different ambient illuminations have to be considered.

These obstacles have to be overcome to enable a proper image acquisition in the context of image processing on mobile devices. There are several advantages to using a smartphone above a traditional camera. smartphone is with the user all the time, making it very easy take a picture. The majority of modern smartphones can easily connect to the internet Once connected you can share photographs from your phone within seconds. Also there are plenty of apps for editing pictures making smartphone camera popular, following areas shows traditional cameras still have a strong upper hand.

- Optical zoom

With an optical zoom, coupled with stronger image stabilizers, user can be adjusting the lens, which will give much better image quality. Smartphones can’t utilize an optical zoom lens purely because of a size limitation.

- Sensor

A camera sensor is what is used to capture a photograph. Sensor captures all the light and turns it into a digital signal. The more pixels a sensor has, the higher the resolution causing more light captured, which is also important for low-light shooting.

- Shutter speed
- Interchangeable lenses

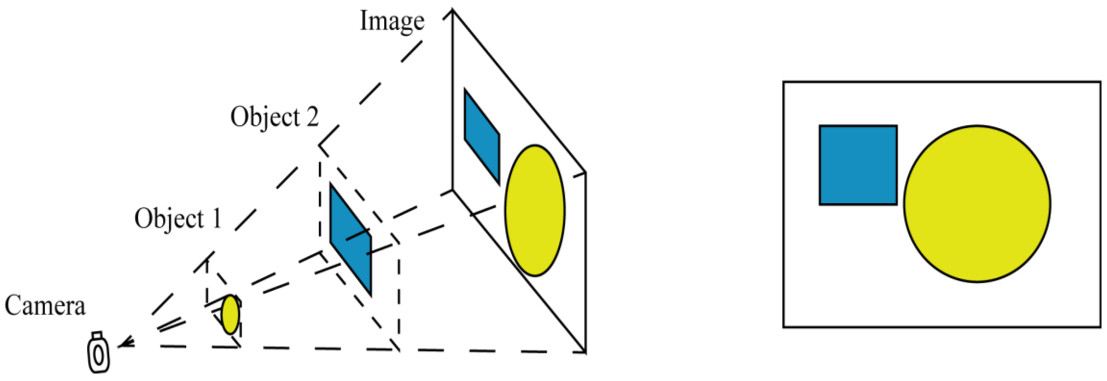



Figure 2.3.2 - Camera view of a scene

According to the image taken by camera closer object seems to larger than far objects but it is reverse in actual world by this theory the to be estimated scale of an actual object is depending on how far it is to the camera. Yet the corresponding object must be isolated from the image to calculate. Considering camera feed a continues series of images (frames) the system needs to go through each and every frame to perform the calculation.

## 2.4 Object Detection.

### 2.4.1 Thresholding

Ability to separate out the regions of the image that correspond to background according to user's wish is which the use of Thresholding. Thresholding often provides an easy and convenient way to perform this segmentation on the basis of the different intensities or colors in the foreground and background regions of an image. In the simplest implementation Thresholding operation converts grayscale or color image to a binary image representing the segmentation. Black pixels correspond to background and white pixels correspond to foreground. Segmentation is determined by a single parameter known as the intensity threshold. Each pixel in the image is compared with this threshold. If the pixel's intensity is higher than the threshold, the pixel is set to white in the output. If it is less than the threshold, it is set to black.

There are two types of thresholding algorithms

- Global thresholding algorithms - a single threshold for all the image pixels is used.
- Local or adaptive thresholding algorithms - When the pixel values of the components and that of background are fairly consistent in their respective values over the entire image.

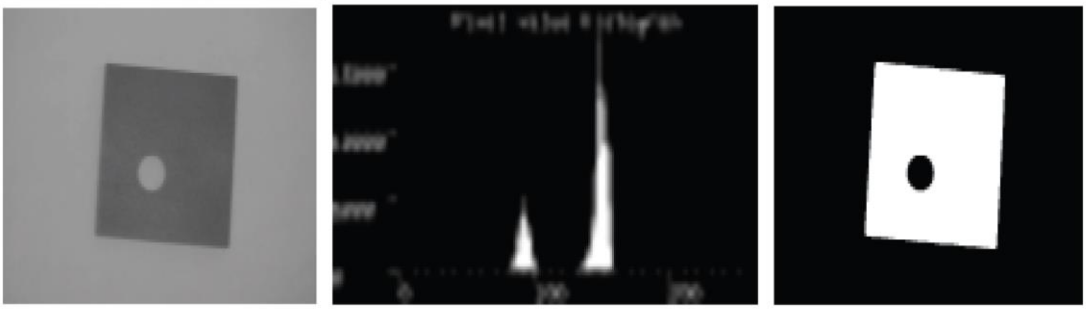


Figure 2.4.1 - (left) Original image (Middle)The histogram for image (right) Threshold image for intensity value of 120.

### 2.4.2 Edge Detection

sudden changes of discontinuities of brightness in an image are called as edges. Significant transitions in an image are called as edges. Edge detection is an image processing technique for finding the boundaries of objects within images. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision. Image segmentation is the process of dividing an image into multiple parts in order to to identify objects or other relevant information in digital images. Following are some of Common edge detection algorithms

- Sobel Edge Detector

In theory Sobel operator consists of a pair of 3×3 convolution kernels as shown in Figure 9. One kernel is simply the other rotated by 90°.

| | | |
|---|---|---|
| -1 | 0 | +1 |
| -2 | 0 | +2 |
| -1 | 0 | +1 |

Gx

| | | |
|---|---|---|
| +1 | +2 | +1 |
| 0 | 0 | 0 |
| -1 | -2 | -1 |

Gy

Figure 2.4.2 - Sobel convolution kernels

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations if applied separately to input image.

The Sobel operator is slower to compute than other operators, but its larger convolution kernel smooths the input image to a greater extent and so makes the operator less sensitive to noise. The operator also generally produces considerably higher output values for similar edges, compared with the other operators.

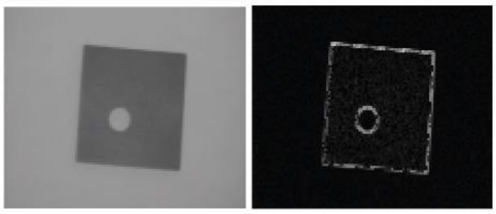


Figure 2.4.3 - (left) Original image (right) edge detect using Sobel

- Robert's cross operator

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of 2×2 convolution kernels as shown in Figure 11 which is very similar to the Sobel operator.

| | |
|---|---|
| +1 | 0 |
| 0 | -1 |

Gx

| | |
|---|---|
| 0 | +1 |
| -1 | 0 |

Gy

Figure 2.4.4 - Roberts Cross convolution kernels

The main reason for using the Roberts Cross operator is that it is very quick to compute. Only four input pixels need to be examined to determine the value of each output pixel, and only subtractions and additions are used in the calculation.

In addition, there are no parameters to set. Its main disadvantages are that since it uses such a small kernel, it is very sensitive to noise.

It also produces very weak responses to genuine edges unless they are very sharp. The Sobel operator performs much better in this respect.

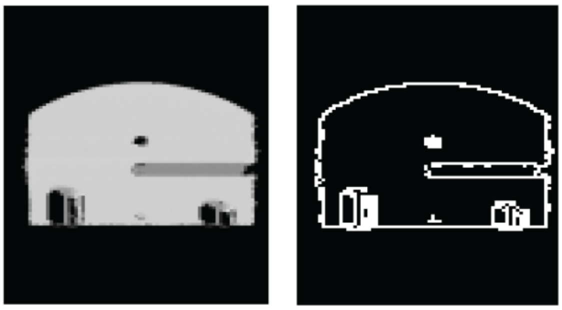


Figure 2.4.5 - (left) Original image (right) edge detect using Roberts Cross

- Canny Edge Detector

The Canny operator was designed to be an optimal edge detector. It takes as input a gray scale image, and produces as output an image showing the positions of tracked intensity discontinuities. The Canny operator works in a multi-stage process. First of all, the image is smoothed by Gaussian smoothing operator which is a 2-D convolution operator that is used to `blur' images and remove detail and noise. Then a simple 2-D first derivative operator is applied to the smoothed image to highlight regions of the image with high first spatial derivatives. Edges give rise to ridges in the gradient magnitude image. The algorithm then tracks along the top of these ridges and sets to zero all pixels that are not actually on the ridge top so as to give a thin line in the output, a process known as non-maximal suppression. The tracking process exhibits hysteresis controlled by two thresholds: T1 and T2, with T1 > T2. Tracking can only begin at a point on a ridge higher than T1. Tracking then continues in both directions out from that point until the height of the ridge falls below T2. This hysteresis helps to ensure that noisy edges are not broken up into multiple edge fragments.

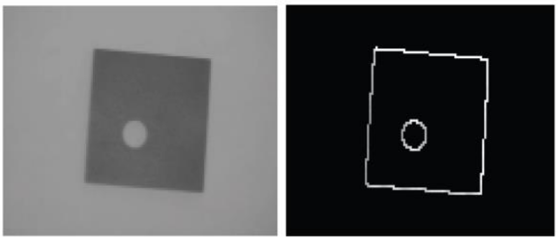


Figure 2.4.6-(left) Original image (right) edge detect using Canny

- Laplacian of Gaussian

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian Smoothing filter in order to reduce its sensitivity to noise. The operator normally takes a single gray level image as input and produces another gray level image as output.

### 2.4.3 Contours

Contours can be explained simply as a curve joining all the continuous points (along the boundary), having same color or intensity. Contours convey key information about object shape and serve as the basis for a variety of local image descriptors such as shape context and geometric blur. The contours are a useful tool for shape analysis

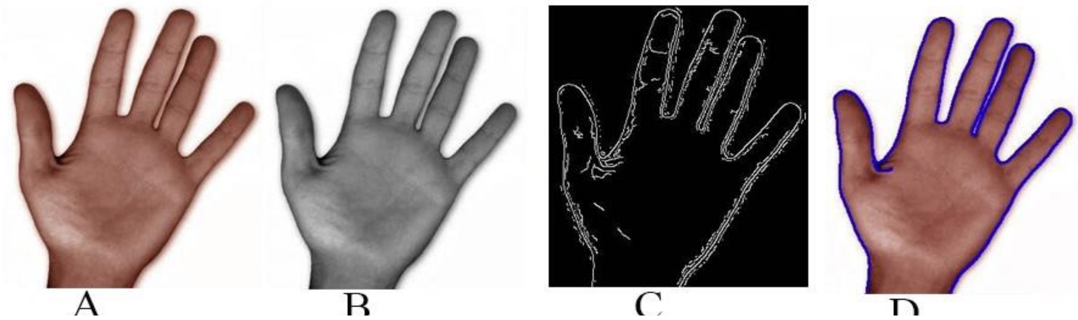



Figure 2.4.7 - (A)Original Image, (B) Gray Scale Image, (C) Edge Detected image, (D) contour of the image

and object detection and recognition. Contours are often obtained from edges, but they are aimed at being object contours. Thus, they need to be closed curves. Image Processing algorithms & libraries define them as boundaries. When they are obtained from edges, you need to connect the edges in order to obtain a closed contour. For better accuracy, use binary images. So before finding contours, apply threshold or canny edge detection.

finding contours is like finding white object from black background. Object to be found should be white and background should be black. After image got segmented it can be process through morphological operations. Appling Morphological operations to threshold image may leads to make the contour more accurate.

### 2.4.4 Appling Morphological operations.

- Opening

Opening is defined as an erosion followed by a dilation using the same structuring element for both operations. The opening operator therefore requires two inputs: an image to be opened, and a structuring element. Graylevel opening consists simply of a graylevel erosion followed by a graylevel dilation. To increase the effect, multiple erosions are often performed with this element followed by the same number of dilations.

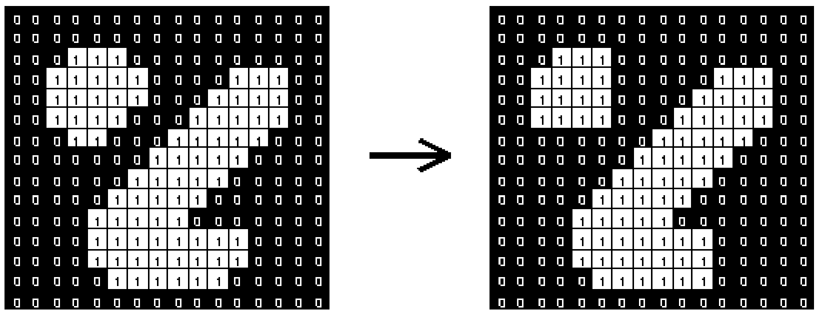


Figure 2.4.8 - Effect of opening using a 3×3 square structuring element

- Closing

Effect of opening using a 3×3 square structuring element It is defined simply as a dilation followed by an erosion using the same structuring element for both operations. One of the uses of dilation is to fill in small background color holes in images

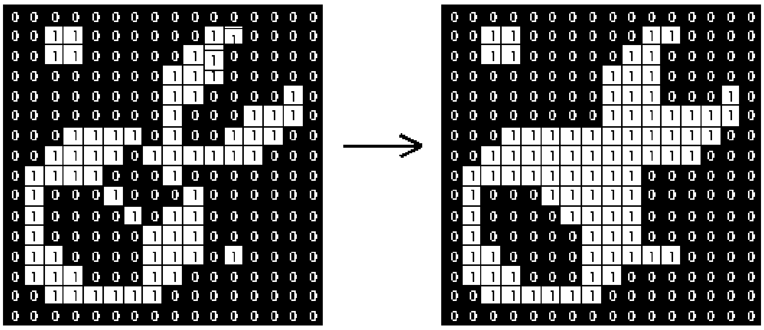


Figure 2.4.9 - Effect of closing using a 3×3 square structuring element

## 2.5 Calculating Height

Camera and photography context tend to talk about lens characteristics in terms of "focal distance" while in synthetic image generator (such as raytracing) tend to think in terms of field of view for a pinhole camera model, or aperture (different meaning to camera terminology). The following discusses (an idealized at least) way to estimate the field of view from the focal distance. The focal length of a lens is an inherent property of the lens. It is the distance from the center of the lens to the point at which objects at infinity focus. Note: this is referred to as a rectilinear lens.

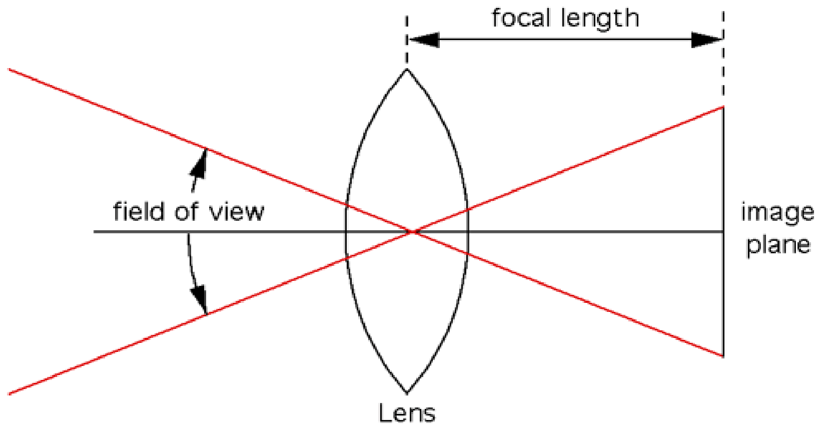


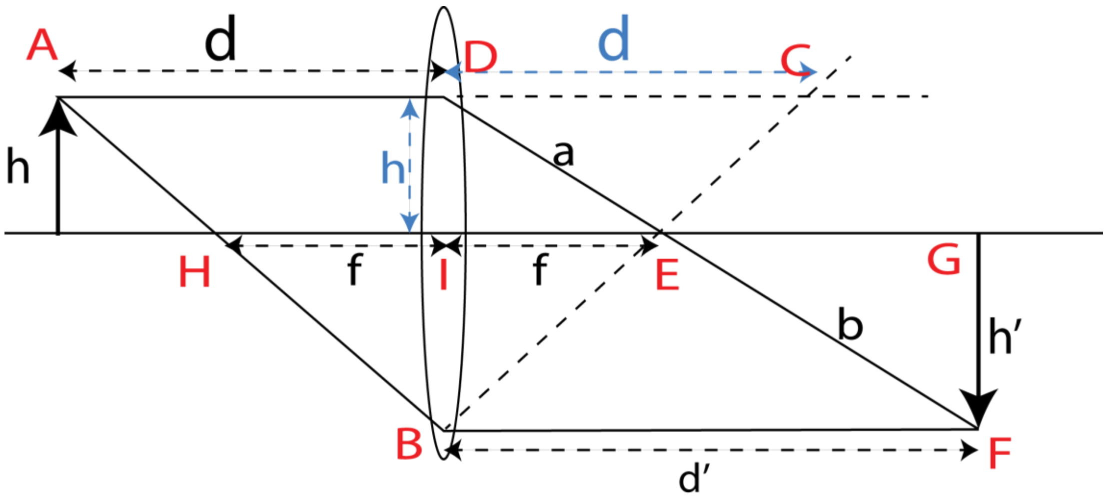

Figure 2.5.1 - Field of view

That there are three possible ways to measure field of view: horizontally, vertically, or diagonally. The horizontal field of view will be used here, the other two can be derived from this. From the figure above, simple geometry gives the horizontal field of view

- horizontal field of view = 2 * atan (0.5 * width / focallength)

The above formula can similarly be used to calculate the vertical aperture using the vertical height of the film area, namely:

- vertical field of view = 2 * atan (0.5 * height / focallength)




$\Delta DCE$ and $\Delta BEF$ are equiangular triangles

$\therefore d/d' = a/b \longrightarrow (1)$

$\Delta IDE$ and $\Delta EGF$ are equiangular triangles

$\therefore h/h' = a/b \longrightarrow (2)$

From (1) and (2)

$h/h' = d/d'$

Considering Smart phone camera

$d' \simeq f$

$\therefore h = (h' * d)/f \longrightarrow (3)$

vertical field of view = 2 atan(0.5 h″/ f)

where h″ = height of the full image

Considering Smart phone camera

vertical field of view = 60 degree angle = 1.0472 radian

$f = h''/2\tan(1.0472/2) \rightarrow (4)$

From (3) and (4)

$h = [2 * (h' * d) * \tan(1.0472/2)]/h''$

Figure 2.5.2 Algorithm for scale identification

## 2.6 Testing and Implementation

Mark-less furniture provide improved scalability and usability of the application using different tolls and technologies while maximizing performance. Following section describes how implementations and testing done in Mark-less furniture application.

### 2.6.1 Implementation

The mark-less furniture application is consisting of four main components as shown in table below.

Table 2.6.1 - System Components

| Component | Component Name | Sub Components |
|---|---|---|
| 1. | Furniture suggestions. | i. Suggestion feature for mobile application with filter search.<br>ii. Identify prominent colors. And Generate suggestions.<br>iii. Development of Web API to access services.<br>iv. Develop database manager application to efficiently insert data records during development. |
| 2. | Augmented reality furniture placement. | i. Implement augmented reality features.<br>ii. Furniture customization.<br>iii. Multiple furniture handling. |
| 3. | Voice recognition. | i. Text to voice feature.<br>ii. Customize furniture according to voice commands. |
| 4. | Scale identification. | i. Identify real world scale to determine the actual scale of furniture. |

Mobile application was facilitated by cloud hosted web API with implemented services and data access protocols through active network (internet) connection. API internally connects to a hosted SQL database to retrieve and manipulate persistence data. Overall interconnection between internal components with system interfaces and hardware interfaces can show as a high-level system diagram (figure 21).

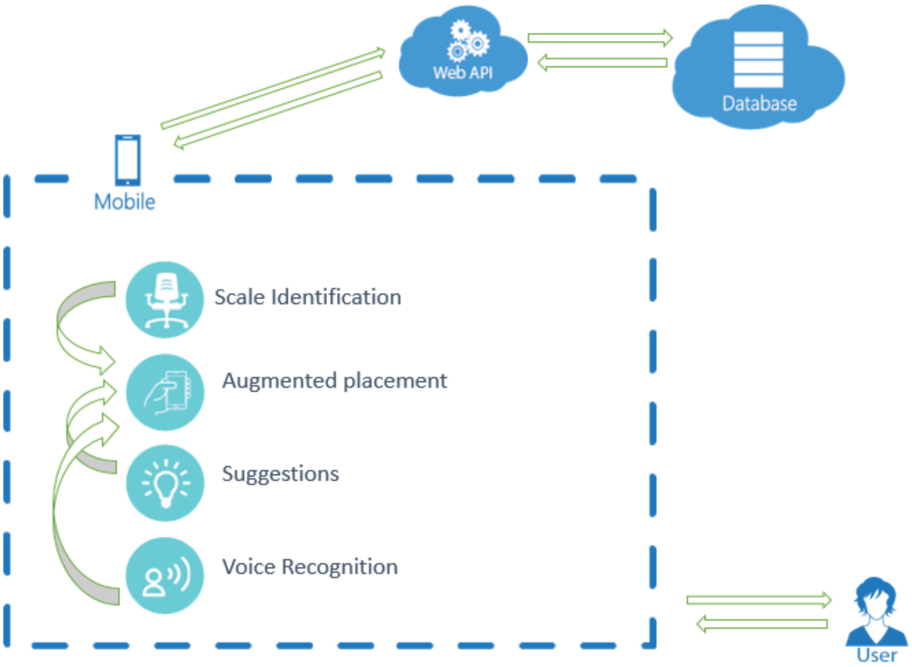



Figure 2.6.1 - System diagram of the Application

- **System interface**

Scale calibration section provide user to change the tracking strength in order to calibrate the system with environment. For scale estimation user need to guess the approximate distance to the tracked object and save scale for proceed with the 3D object placement. Figure 22 shows the implemented window of the Mark-less furniture mobile application.


Figure 2.6.2 - Implemented Scale calibration window

- **Hardware interfaces**

Mobile device with android operating system is used as the main deployment environment for the Mark-less furniture system. The mobile device should consist of following hardware specifications in order to gain the maximum benefit of the application.

  - Accelerometer
  - Magnetometer
  - Gyroscope

- **Communication interfaces**

Since the API is hosted in a web server, active internet connection in mobile device is required for data communications with the server. A minimum bandwidth of H+ (HSDPA) is required to operate the application efficiently through the HTTP communication protocol.

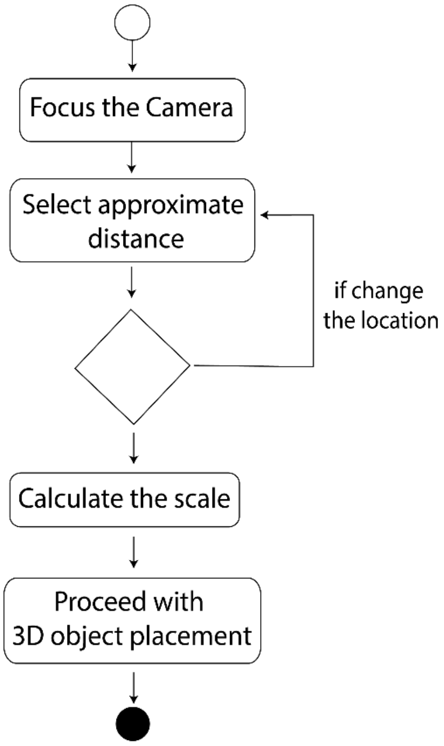



Figure 2.6.3 - Activity diagram for Scale calibaration section

### 2.6.2 Testing

The “Markless Furniture” Application was unit testing during the process of development in order to ensure that each module functioned according the expected output, and tested during the integration of each module to ensure that no new errors were caused. Finally, the overall system is tested against its specifications to ensure that the final product is error free and usable by the end user. User acceptance testing was conducted by two users in the furniture industry. Since performance is a major issue in issue in networked application, the “Markless Furniture” application was tested thoroughly for performance issues.

**Performance Requirement**

i. The mobile application should possess a captured image and generate suitable furniture suggestions within 30 seconds when captured under normal light conditions.
ii. Each web API function should complete execution within 15 seconds.
iii. The mobile application should process a captured image and generate suitable furniture suggestions within 45 seconds when captured under low light conditions.

**Assumptions**

i. Network Connection
The network should possess download bandwidth at least of 7.2Mbits/seconds and upload bandwidth at least of 3.6Mbits/second for normal performance.
ii. Memory
The mobile device memory should above 512 MB to run the application on normal conditions.
iii. Version of Operating System
The mobile device operating system should be of android operating system, version above 4.1 (Jelly Bean).

# 3 RESULTS AND DISCUSSION

## 3.1 Results

"Markless Furniture" is an application for improving the issue furniture marketing, and to ease the difficulties faced by both customers and dealer. The system was a success as it has received numerous positive feedbacks from both parties.The product

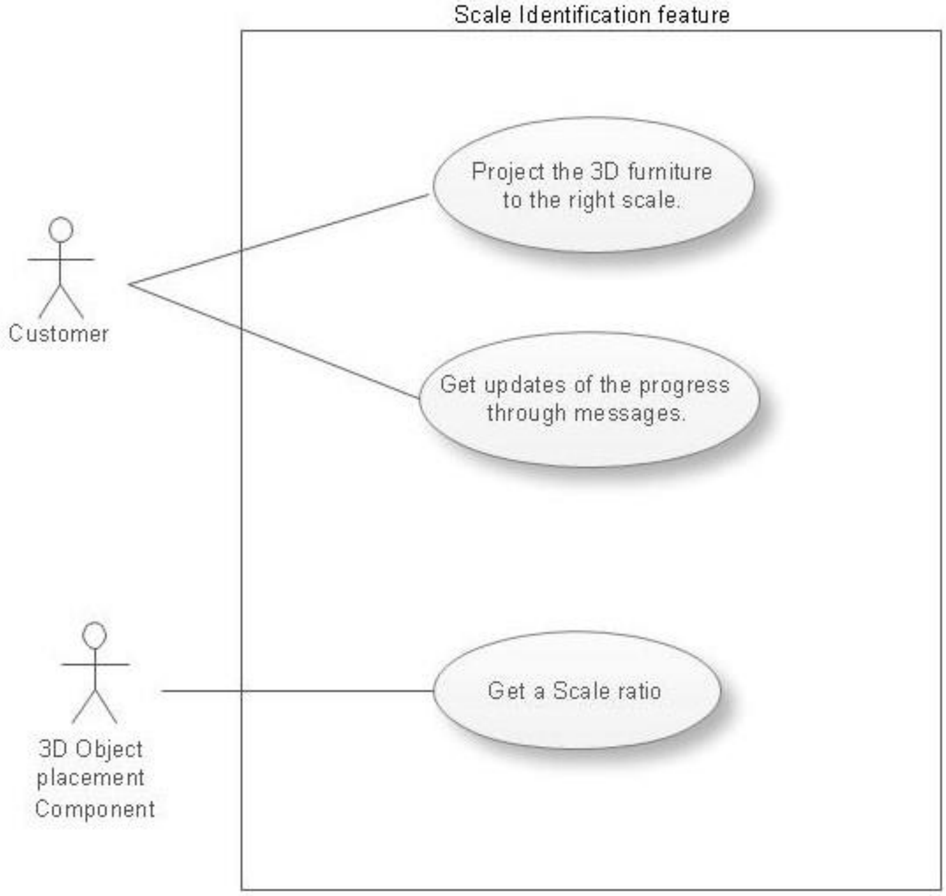



Figure 3.1.1 - Use case diagram

has been proven to operate in a wide range of mobile phones which operates on android 4.3 or newer. The application has been tested for operation under different internet connections and performance capabilities.

Table 3.1.1 - test case 01

| Test case # | Description | Pre-conditions | Test Steps | Input | Expected output |
|---|---|---|---|---|---|
| 01 | Scale Identification<br><br>Success. | • Device is connecting to the internet<br>• Application is open | 1. App comes to the initial page<br>2. Direct to the environment<br>3. Look for warnings and messages | N/A | • Application Gives a message" Scale identified "message on the screen. |

Table 3.1.2 - test case 02

| Test case # | Description | Pre-conditions | Test Steps | Input | Expected output |
|---|---|---|---|---|---|
| 02 | Scale Identification<br><br>Unsuccessful. | • Device is connecting to the internet<br>• Application is open | 4. App comes to the initial page<br>5. Direct to the environment<br>6. Look for warnings and messages | N/A | • Application gives a message" Scale identification unsuccessful "message on the screen. |

System was tested to estimating standard A4 sheet height with different distances. Which is 21cm

- Test01

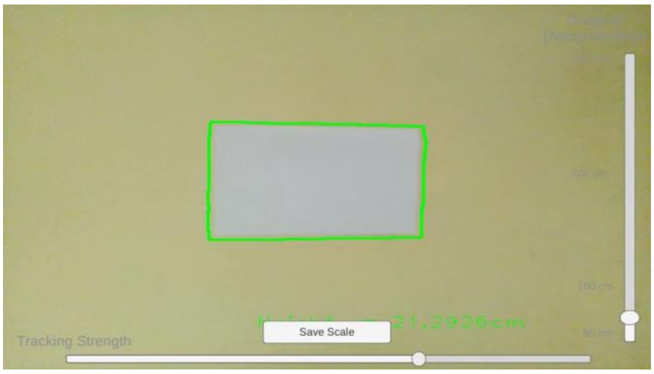



Figure 3.1.2 - A4 sheet in a distance of 60cm.

- Test2

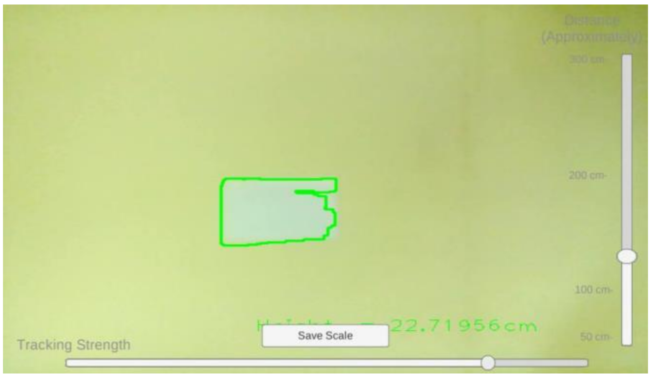



Figure 3.1.3- A4 sheet in a distance of 120 cm

- Test03

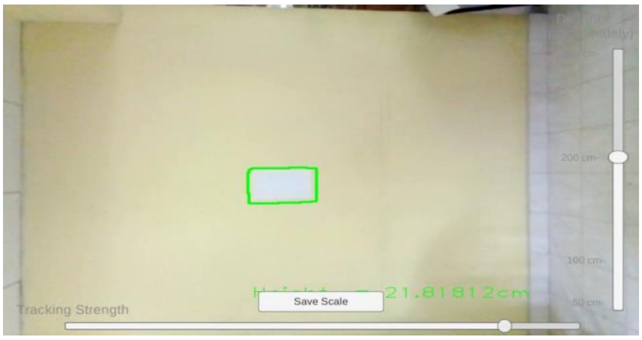



Figure 3.1.4 - A4 sheet in a distance of 200 cm

### 3.2 Discussion

The discussion part is mainly focused on discuss about problems faced during the project design and implementation and how those issued are solved. This section also describes how the successful achievements are gained. Most of the software products consist of different kind of bugs. It is our responsibility to minimize the number of bugs before releasing the product to the end user.

# 4 CONCLUSION

Over the past few decades' improvement of new marketing strategies reached an advanced level. With invent of new smart phones goals of marketing have moved towards the mobility and reachability from traditional techniques. This increase the number of customers reaching a particular business and thus the satisfaction ratio of the customer should be increased in order to earn a market value among other competitive businesses.

This research provides a modern solution to the furniture marketing industry in order to increase the customer satisfaction while surviving in the competitive business world. The identified solution mainly focused on providing augment reality or a mixed virtual experience to the users which facilitate them to interact with computer generated 3D models placed on their environment.

Filling the simulation gap of projecting 3D furniture scaled irrelevantly according to the environment provide users to get a real experience through virtual furniture improving client interaction and faster decisions to make a purchase. Reduction of wrong customized orders and cut down of operational costs and time also a support the large impact on the furniture industry.

# REFERENCES


[1] Sisi Zlatanovaa, George Sitholeb, Masafumi Nakagawac, Qing Zhud,” PROBLEMS IN INDOOR MAPPING AND MODELLING”, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-4/W4, 2013 ISPRS Acquisition and Modelling of Indoor and Enclosed Environments 2013, 11 – 13 December 2013, Cape Town, South Africa.

[2] C. Holzmann and M. Hochgatterer, "Measuring Distance with Mobile Phones Using Single Camera Stereo Vision", 2012 32nd International Conference on Distributed Computing Systems Workshops, 2012.

[3] Mahdi Momeni-K., Sotirios Ch. Diamantas, Fabio Ruggiero and Bruno Siciliano,” HEIGHT ESTIMATION FROM A SINGLE CAMERA VIEW”

[4] Sanni Siltanen, "Theory and applications of marker-based augmented reality," 2012.

[5] Daniel Platisa and Saman Heidari, "Furniture Retailing in the Times of Augmented Reality," Bachelor Thesis, Gothenburg School of Business, Economics and Law, 2015.

[5] Elizabeth Carvalho, Gustavo Maçães, Isabel Varajão, Nuno Sousa, and Paulo Brito, "Figures Figure Enlarge Figure Enlarge Figure Enlarge + 6 Full-text (PDF) Available from: Elizabeth Simão Carvalho Use of Augmented Reality in the furniture industry," 2011.

[6] K. N. Kutulakos and J. R. Vallino, "Calibration-free augmented reality," *IEEE Transactions on Visualization and Computer Graphics*, vol. 4, no. 1, pp. 1–20, 1998.

[7] Alper Yilmaz, "Object Tracking and Activity Recognition in Video Acquired Using Mobile Cameras," University of Central Florida Orlando, Florida, 2004.

[8] Joseph Schlecht and Björn Ommer, "Contour-based Object Detection," Proceedings of the British Machine Vision Conference (BMVC), 2011.

[9] R. C. Gonzalez, R. E. Woods, D. J. Czitrom, and S. Armitage, *Digital image processing*, 3rd ed. United States: Prentice Hall, 2007.

[10] lindsay, "Augmented reality for interior design," Augment, 2016. [Online]. Available: http://www.augment.com/augmented-reality-for-interior-design/. Accessed: Feb. 31, 2016.

[11] V. LTD, "UDecore - home decoration with augmented reality," 2013. [Online]. Available: http://www.viutek.com/udecore.html. Accessed: Feb. 31, 2016.

[12] Sayduck, "Home," Sayduck, 2016. [Online]. Available: http://sayduck.com/business/. Accessed: Feb. 31, 2016.

[13] Realmore, "Try furniture in real time, buy with confidence,". [Online]. Available: http://www.augmentedfurniture.com/. Accessed: Feb. 31, 2016.