# Background Research

Besides giving some background research on the technologies applied in this project, the following chapter will describe in detail technical information of the workplace environment and the applicable technologies to apply current Augmented Reality technologies for such environments as well as the difficulties which arise along.

## User Profiling

``User Profiling is the process of Extracting, Integrating and Identifying the keyword-based information to generate a structured Profile and then visualizing the knowledge out of these findings” [13]. Through user profiling the system is capable to tailor the required information for the user to see and make use of. It is annoying for users to have to go through irrelevant documents or data to find what is specific to what they require.

``User profile generation is done when we get users’ complete information while he registers into our system. We have identified different user attributes for profiling him into our system"[13]. User profiling has taken the form of recommender systems, where the system provides user specific recommendations in a personalized form. There are two forms of User profiling. Explicit User profiling, “In this approach users’ behaviour is predicted by analysing the user’s available data” [12]. This is known also as static profiling, in which analysis of static and predictable user data is made. The second type is implicit User profiling, it “relies more on what we have known about user in future i.e. systems tries to learn more about the user” [12]. It is also referred to as Adaptive Profiling. After performing extraction, one might end up with redundant information.

To clean the information and see unique pieces of it, one must perform filtering. There are three filtering techniques for user profiling; rule-based, collaborative, and content-based filtering techniques. Content based filtering, ``recommends items based on a comparison between the content of the items with a user profile and selects those items whose content best matches with the content of another item"[12]. Collaborative Filtering is the process of grouping users with a similar search criterion. The filtering is based on previous sought items as well and items which they are more likely to search for next.

## Augmented Reality

``Augmented Reality (AR) is a new technology that involves the overlay of computer graphics on the real world” [23]. It is a term which refers to mixed reality, where the digital world and reality are combined and interwoven together. Augmented Reality is a new form of technology that focuses on displaying realistic overlays on reality to provide extra information and content to what we see with our naked eye.

There are different categories of Augmented Reality. The first category is, marker-based AR, where the augmented overlay is only displayed once a marker is detected through a camera. It is also known as image recognition. The second category is, markerless augmented, which makes use of an accelerometer, a GPS and velocity tracker to detect the location of the phone and display the AR overlay in that specific location, given its location is predefined. The third category is projection based which basically projects data in the form of light rays on objects, for example an augmented-projected keyboard. The last category is superimposed AR, where the AR partially replaces the real view with an augmented one of that objects, IKEA makes use of this application through their digital catalogues.

There are several Augmented Reality Devices. The first category is Optical See-Through HMD. ``Optical See-Through AR uses a transparent Head Mounted Display to show the virtual environment directly over the real world” [23]. HMD performs best when it’s perfectly fits to the user’s eyes and sit comfortable on their face, making it easy for the users to move around with them worn. The second category are Virtual Retinal Devices. ``The VRD projects a modulated beam of light (from an electronic source) directly onto the retina of the eye producing a rasterized image” [23]. The third category Video See-Through HMDs, the monitor based Augmented Reality which ``uses merged video streams but the display is a more conventional desktop monitor or a handheld display” [23]. Finally, the projection displays which projects on surfaces and is useful for multiple user interaction. One such example of projection-based AR is Tilt Five.

## Mobile Augmented Reality

Using Augmented Reality on mobile devices presents several challenges. Such problems are ``related to context-awareness, usability, navigation, visualization and interaction design" [15]. Nowadays handheld devices are equipped with powerful processors, cameras, and sensors. Smartphones use ``camera on the opposite side of the display encourages the use of the ‘magic lens’ metaphor describing the fact that the users have to point and look ‘through’ the device to view the augmented representation of the real world" [15]. Although most cameras are equipped with high resolution, the screen as well as the camera capture a limited range of field of view. Therefore, augmented information must clearly be placed on the smartphone screen and not obstruct the user from important views of the real world.

A mobile augmented reality framework is made up of three specific features as presented in [14]; the MAR Observer obtains the target images or text from the augmented reality server, MAR Server which "serves as a bridge between the MAR customizer and MAR observer" [14], and the MAR application customizer which defines interactions between the user and the image targets. In this case, Vuforia serves as the MAR application customizer.

## Augmented Reality Navigation

Outdoor navigation normally makes use of GPS localisation. However, for indoor navigation this can be a problem. There are several ways how to provide indoor localisation. One can make use of beams either by Bluetooth signals or WIFI signals. This will provide the user with continuous mapping, but it has also resulted to be buggy at times. The alternative to that is by using offline waypoints. The user simply scans a marker to get a location or augment pre-programmed information within that location. ``the user needs to update his/her location by scanning another way-point on the way" [6].

One main challenge in augmented reality navigation is the process of registration. ``Registration is the process of correctly aligning the virtual information with the real world in order to preserve the illusion of coexistence” [6]. Although proper visual registrations must be met for the Augmentation to be as realistic as possible, one must not forget that the user still needs to focus on what is on their path.

The improvement of AR can help provide navigation information without distracting the user from looking away to a secondary screen or view, ``For example, showing navigation markers on the windshield of the car or augmenting the video camera output of a smartphone with the navigation path” [6]. To provide an augmented reality navigation system there are several steps one need to take, ``1. Acquire the real-world view from the user’s perspective. 2. Acquire the location information for tracking the user. 3. Generate the virtual world information based on the real-world view and the location information. 4. Register the virtual information generated with the real-world view” [6].

## Traditional Computer Vision for Object Detection

Traditional computer vision is the ``traditional approach is to use well-established CV techniques such as feature descriptors (SIFT, SURF, BRIEF, etc.) for object detection" [1]. Images contain several features which can be extracted, using CV algorithms such examples would be edge detection, corner detection as well as threshold segmentation for improved detection of such features may be involved.

Image recognition works by detecting natural features such as edges and corners in an image. ``the feature tracking algorithm can determine what is a feature and map the positions of these features in the image" [10]. By shifting the positions of the image features like edges are intensified, even more corners as their position changes after shifting. Vuforia thus, makes use of Pose feature detection techniques where it takes into consideration the position and orientation of the natural features. It can make use of extended tracking, where the engine detects surrounding features as well. A proper image with high quality feature detection is an image that contains uniquely distinct features, which are not repetitive. For example, a dark circle is difficult to recognize and establish uniquely features.

``The difficulty with this traditional approach is that it is necessary to choose which features are important in each given image. As the number of classes to classify increases, feature extraction becomes more and more cumbersome. It is up to the CV engineer’s judgment and a long trial and error process to decide which features best describe different classes of objects" [1]. There are several advantages when using traditional computer vision techniques. SIFT and SURF algorithms are generally used for applications such as image stitching, where classes do not need to be identified within the image. Traditional techniques make use of less processing power and the problem at hand is simple enough to use such traditional computer vision techniques with little amount of data needed, unlike a deep learning model.

## Deep Learning in Augmented Reality

The detection problem has been solved using camera-based tracking systems to apply it to Augmented Reality, using deep learning techniques. The Vuforia Library has applied such techniques to scan 3D objects and create model targets for them, to be easily recognizable within any developed AR app. This provides new advantages such as detect-ability from any angle of the recognizable real-world object. “Known model of the object can be used to determine the position and orientation of the object. Rendering of the virtual object follows easily” [3]. There are two ways how the object can be recognized. One can use traditional artificial vision techniques or use Convolutional Neural Networks for improved detection.

Model-based AR tracking is achievable in two steps. Firstly, using video tracking which “yields the pose of the camera with respect to the known target” [3]. Secondly, the pose is sent to an algorithm for tracking. For detection, algorithms such as SIFT and SURF are commonly used. It extracts a number of key points using a corner detection algorithm such as FAST [21]. In [3], a CNN implementation was trained using AlexNet to detect patches. FAST was used to detect features on a reference image, it extracts 15 by 15 patches across each feature. HIPS [24] was used for 8 by 8 for sparse sampled patches from the original set of patches. When comparing the overall performance of the CNN used in [3] with an algorithm such as ORB the re-projection error shows that it was far improved in the DeepAR. “DeepAR method produces consistently more inliers than HIPS. However, as can be seen in Figure 12 the percentage of inliers vs outliers are less for DeepAR” [3].

In the study conducted within [3], it is concluded that “The detector performance is very strong especially in the presence of error in feature localization”\cite{ Akgul2016ApplyingDL}. It is comparable to one of the best feature detection algorithms to date.

## Conclusion

In this chapter, background research and information on existing technologies and techniques which will be applied in the FYP have been discussed. In the following chapter, a literature review of the research published in the area of Augmented Reality is presented.

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