# Background Research

Besides providing some background research on the technologies applied in this project, this chapter will discuss thoroughly technical information about the workplace environment and applicable technologies in order to apply current Augmented Reality technologies in such environments, while outlining any difficulties which might arise.

## 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]. User profiling enables the system to tailor the required information for the user to see and use. It is rather annoying for users to have to go through irrelevant documents or data in an attempt to find information specific to what they require.

“User profile generation is done when we get user’s 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, thus providing user specific and personalised recommendations. There are two forms of user profiling. The first is Explicit User Profiling, which is an approach where the “…user’s behaviour is predicted by analysing the user’s available data” [12]. This is also known as Static Profiling, where static and predictable user data is analysed. The second type is Implicit User Profiling, which “relies more on what we have known about user in future i.e. system tries to learn more about the user” [12]. This type 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, namely, rule-based, collaborative, and content-based filtering. Rule-based filtering is the technique used to filter out content based on a set of rules, normally present using “if-then” statements. 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]. On the other hand, collaborative filtering is the process of grouping users with a similar search criterion. Filtering is based on previously sought items as well and items which one is 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. 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 eyes.

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, 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 AR replaces partially the real view with an augmented one of the object. IKEA use this application in their digital catalogues.

There are several Augmented Reality devices. The first device 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 fits perfectly to the users’ eyes and sits comfortable on their face, making it easy for them to move around when wearing it. The second type is Virtual Retinal Device, which “…projects a modulated beam of light (from an electronic source) directly onto the retina of the eye producing a rasterized image” [23]. The third device is Video See-Through HMD, 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, projection display, 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 which are “related to context-awareness, usability, navigation, visualization and interaction design" [15]. Handheld devices are nowadays equipped with powerful processors, cameras, and sensors. Smartphones use a “camera on the opposite side of the display [which] 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 and camera capture a limited range of field of view. Therefore, augmented information must clearly be placed on the smartphone screen and avoid obstructing the user from important views of the real world.

A mobile augmented reality framework is made up of three specific features [14], namely, MAR Observer which 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 MAR application customizer which defines interactions between the user and image targets. In this case, Vuforia serves as the MAR application customizer.

## Augmented Reality Navigation

Outdoor navigation usually makes use of GPS localisation. However, this can be a problem for indoor navigation. There are several ways to provide indoor localisation. One can use beams either by Bluetooth signals or WIFI signals thereby obtaining continuous mapping, albeit with rather irregular results at times. The alternative is to use offline waypoints, where the user simply scans a marker to get a location or augment pre-programmed information within that location. However, “…the user needs to update his/her location by scanning another way-point on the way" [6].

One main challenge of augmented reality navigation is the process of registration, which “…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 in their path.

Improvement of AR can help to provide navigational information without distracting the user to look away to a secondary screen or view by, “[f]or 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 needs to take, namely, “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…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 as, edge detection, corner detection, and threshold segmentation for improved detection of such features.

Image recognition works by detecting natural features such as edges and corners in an image. “[T]he 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, with even more corners as their position changes after shifting. Therefore, Vuforia 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 recognise and establish as a unique feature.

“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 them to Augmented Reality using deep learning techniques. The Vuforia Library has applied such techniques to scan 3D objects and create model targets for them in order to be easily recognisable within any developed AR app. This provides new advantages, such as, detectability from any angle of the recognisable 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 recognised. One can use traditional artificial vision techniques, or Convolutional Neural Networks for improved detection.

Model-based AR tracking is achievable in two steps. Firstly, one uses 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. Such algorithms as SIFT and SURF are commonly used for detection. The algorithm 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, extracting 15 by 15 patches across each feature. HIPS [24] was used for 8 by 8 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 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 their study, [3] concluded that “[t]he detector performance is very strong especially in the presence of error in feature localization” [???] \cite{ Akgul2016ApplyingDL}. It is indeed comparable to one of the best feature detection algorithms to date.

## Conclusion

This chapter provided and discussed background research and information on existing technologies and techniques which will be applied in FYP. The following chapter will present a literature review of the research published in the field of Augmented Reality.

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