# Future Work

Based on this Final Year Project, future work and improvements include the following:

* To initially encourage the company to either make use of a smaller prototype dataset of user-ratings tailor made for them, make use of a random walk algorithm which provides random paths between users who previously made use of the application, or simply initially allow the user to make his own decisions until a large enough dataset is built and ready to apply collaborative ﬁltering techniques to.
* To phase into using deep learning instead of machine learning, or matrix factorisation methods for collaborative ﬁltering techniques, which would also be applicable to smartphone devices. This will only be possible once a large dataset is built to avoid under or overﬁtting. The research done in [39] proposes an alternative to SVD++, where the deep learning model converged faster and achieved better RMSE values. However, the deep learning model must be portable enough for smartphone devices to run eﬃciently, rather than exhaustively.
* To switch from oﬄine to online. This would only be possible if there is internet connection within the building and is well protected to protect the company from any hacking. This may yield several advantages, such as, storing machine learning or deep learning models online, rather than on the portable device itself. The user ratings can be done on the ﬂy, and the datasets could be updated eﬃciently in real time.
* To improve the User Interface, making instructions and augmentations more interactive as well as user-friendly. Users may also have the option to select a UI theme of their preferred choice.
* To improve markers recognition without having to pan the smartphone due to switching from traditional computer vision techniques to deep learning techniques when augmenting information about oﬃces. The Vuforia library could further launch new releases that would allow one to make use of multiple model targets in one Unity scene, which will ultimately remove the need to have to use image targets in combination with model targets, and simply make use of model targets instead, thus solving the smartphone panning issue.
* To include holographic live direction, giving arrows instead of a holographic map as recommended by some participants within the survey. This may be implemented using location-based augmented reality using internal signals rather than GPS since the application is to be run indoors. Such signals could be implemented only if the company is willing to invest in strong indoor positioning systems, such as, proximity-based, WIFI-based, ultra-wide band, acoustic, or infrared systems. However, one then would need to make use of other augmented reality libraries, such as, ARCore or ARkit, instead of Vuforia since it does not support location-based AR. Another alternative would be to build very accurate and detailed 3D models of the workplace which could be fed within the Vuforia library on which to apply deep learning techniques. However, the workplace would need to provide plots of the interiors for 3D modelling. A similar approach was initially tested within the library using image targets, as shown in Figure 72. However, this was deemed ineﬃcient since, as previously explained, large spaces of environment are prone to constant change by day, which will ultimately aﬀect the AR application’s eﬃciency and the user’s experience. Furthermore, Vuforia had diﬃculty recognising most corridors since it had no distinctive features to recognise.
* To allow users to interact with the real world through augmented reality, as proposed and tested in [34], where users interact with real world devices, such as, lighting, fans, and other forms of hardware via augmented reality. This may be applied to the workplace to book offices for meetings by recognising the oﬃce door sign marker and interacting with the company’s shared calendar.
* To include explainable AI which provides a set of tools and frameworks to implement machine learning models which can easily be interpreted and understood by the users. One can easily understand certain decisions taken by the artiﬁcial intelligent models rather than merely be presented with their results. It improves transparency with human-interpretable explanations, hence providing any patterns found within the applied models.

# Conclusion

To conclude, this report presented an approach to applying a workplace assisting augmented reality using Vuforia’s computer vision approaches, traditional methods, and deep learning combined to work harmoniously together. Proper analysis was made of the environment to which WAAR was to be applied to thereby making use of the best possible markers for the application in order to run eﬃciently without hindering the user’s experience.

The library’s models were trained on images taken there, and 3D models were generated and modiﬁed using Selva3D and Blender3D, respectively. No predeﬁned datasets could be used for the current context where WAAR was used because the application had to be tailor made for the workplace. In total, 11 markers were used from the first floor of the workplace, and were subject to qualitative testing by employees from the workplace itself, as well as external people who did not work there. The quantity testing carried out on the augmented reality side of the application has shown the limits of the application. It has successfully worked well when tested on distance, rotation, occlusion, and colour variance, achieving on average positive results.

The recommendation system was successfully implemented within the augmented reality application to provide users with recommendations for locations they might be interested in, depending on two important factors, namely, previous users’ preferences respective to the task they had, and recommendations based on locations they might pass in front of while completing a particular task. This was implemented using a combination of collaborative ﬁltering approaches using matrix factorisation via SVD++/SVDpp model and item-to-item based similarity, respectively. Datasets had to be generated simply to prototype the application. However, the built datasets were based on norms carried out within the workplace. The SVD++ model was successful when compared to other algorithms, achieving average RMSE and MAE values of 3.1226 and 2.6866, respectively, with an average ﬁt time of 0.1053 seconds and average test time of 0.0023 seconds.

The results obtained are not surprising and are indeed promising, highlighting the fact that augmented reality can be applied to the real world using the techniques mentioned in the objectives. It was thus beneficial to achieve successfully the results. However, one should not ignore or overlook the fact that there will always be room for improvement and innovation.