# 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 prototype smaller dataset of user-ratings tailor made for them, make use of a random walk algorithm where it provides random paths between user’s 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 for 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 eﬃciently rather than exhaustively run.
* To switch from oﬄine to online. This would only be possible given there is an internet connection within the building and is well protected to safe protect the company from any hacking. This may bring 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 of selecting 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 of having to use image targets in combination with model targets, and simply just 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 to apply deep learning techniques on. 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 seen as ineﬃcient as previously explained large spaces of environment are prone to constantly change by day which will ultimately aﬀect the AR application’s eﬃciency and the user’s experience and as well Vuforia had diﬃculty to recognise most corridors due to not having any 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 for workplace for booking oﬃces for meetings by recognising the oﬃce door sign marker and interacting with the company’s shared calendar.
* To include explainable AI. Explainable AI 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 just be presented with their results. it improves transparency with human-interpretable explanations hence providing any patterns found within the models applied.

# Conclusion

To conclude, this report presented an approach to applying a workplace assisting augmented reality using Vuforia’s computer vision approaches, the 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, in order to make 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 made use of for the current context WAAR was used in, because the application had to be tailor made for the workplace. In total 11 markers were used from the workplace’s ﬁrst ﬂoor and was subject to qualitative testing by employees from the workplace itself as well as external people which 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 which were: previous user’s preferences respective to the task they had and recommendations based on locations they might pass in front of whilst 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, datasets built were based on norms carried out within the workplace. The SVD++ model was successful when compared to other algorithms achieving an 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 promising. Highlighting the fact that augmented reality can be applied to the real-world using the techniques mentioned in the objectives. Successfully achieving the results was beneﬁcial. However, one should not ignore the fact that there will always be room for improvements and innovation.