# SUMMARY

I have had a pleasure to work on this amazing project with an amazing instructor Mr. Vladislav-Veniamin Pustynski. Our goal was to place stars in Apollo 14 surface imagery. In the pictures, celestial objects are not present due to the following reason. The exprosure times of the photographs were chosen by the astronauts so that the lunar landscape, hardware and the astronauts themselves were registered in the optimal way. However, these exposure times are insufficient to register stars, that require much longer exposures. In an extreme case, Venus was registered in some photographs. It worth mentioning that Venus was more than 10 times brighter than the brightest star, Sirius. My instructor came up with a solution and since this is meant to be my work, he was giving me hints and sometimes helping to understand concepts so I could myself get to the solution. Discussions with Mr Pustynski sometimes lasted till 2:00 am, however due to his ability to communicate with students, the time was passing faster than I could have imagined and at the same time I was comming to better realisations. The data I was provided with included camera indexes, azimuths, elevations, roll anglees and and focal lengths. These data were obtained as a result of photogrammetric analysis of the surface imagery. I furthermore found the pixel distance between crosses and ground level for each camera and added it to my data spreadsheet. I worked on 11 images and 132 stars, the data of which I have collected from Stellarium (the planetarium providing azimuth and elevation of celestial objects at a given time and location on the Moon). I used Pycharm, a software for building Python-based applications.

In order to locate and place stars in the images, we have to first know the pointing direction of the camera and the direction to the star, thus first I find the unit vectors of both. The plan was to build the image plane, where I would place a circle with the radius equalling to the distance between the object and the principal point of the image, as well as the angle between the local x-axis and object. I closely followed the instructions and tackled some challenges. Eventually, I succeeded and came up with a Python code that works on multiple images and a large number of stars.

The code places stars to photographs with an accuracy of about 23 pixels or better, the accuracy margin being set by the accuracy of the photogrammetric model. I believe this project has been something very unique to me, I plan to continue working on it even after my thesis is done. I see technical places which I could improve, however unfortunately I did not have enough time to add more fuctionality to the code. Together with my instructor I want to add new functionalities and cover wider range of tasks, which are drawing constellations, plotting the true local horizon in the images together with cardinal directions, plotting coordinate grid onto the sky and the ground. I am also willing to take on totally different tasks from here on with my supervisor and work on

them together. Overall, I would like to thank again Mr. Pustynski for being my instructor, mentor, teacher, friend these times and I am happy to be given an opportunity to be working so closely with him on such interesting project. I believe locating stars on Apollo 14 surface imagery is the best project that I have ever worked on. The resulted images and panorama can be found in Appendix.