Experiment Proposal for the Octanis 1 Mission

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The principal objective of Octanis1 mission is to assess and verify the qualities and the limits of the designed autonomous rover. The purpose of this proposal is to define an experiment with the two-fold objective of both exploiting the capabilities of the robot during a scientific mission and push it to the limit of its capabilities.

The experiments will be carried around the Maldonado base on the Greenwich Island. The Scientific Base is situated North-East from Mt. Plymouth and is separated from the Arturo Prat Base by the Discovery Bay. Its geographical location, hence its isolation, make the base an environment as close as possible to a laboratory sample in a sterile box for what regards the impact of human behaviour on the environment.

The experiments will be carried for 30 days and they will aim to highlight both long and short term impact of human inhabitants on the area. Moreover, as far as it extends the author's comprehension on the matter the gathered data might be used for a more global analysis of the effects that pollution has on the glaciers.

According to [1] it is possible not only to use three-dimensional *excitation-emission-matrix* (EEM) spectroscopy to detect *dissolved organic matter* (DOM), but to identify correlation between DOM, presence of micro and macro algae and eutrophication. The last one is a clear index of pollution that is caused by both non-point and point sources. In the last category lie waste waters. In addition [2] sketches an algorithm for fast identification of bacteria from samples. The above results constitute the theoretical basis of the designed experiments. The main questions whose answers has to br sought are: What is the impact of the human presence in an isolated environment? Is it possible to trace such impact in the past? How do the meteorological conditions influence the impact?

I. Task: Snow and Ice Sampling

During this phase the rover collects snow and ice samples from the area surrounding the base and from further locations. Due to the author's lack of knowledge about the rover performance is not possible to define a precise area. The number of samples should be statistically meaningful (a first guess could be 15 per day, depending on the robot capabilities) and they should be sampled always from the same areas in the same day and not in the same order (so to avoid unwanted time correlations). The area can be divided using a grid of a suitable shape (e.g. octagonal). Each grid is visited with random order. To identify the sampling area inside a grid, a Multivariate Gaussian distribution is centred in the zone. Mean and variance have to be chosen in such a way that the distribution in adjacent cells will overlap with a very low probability (e.g. 5%).

I.1 Expected Outcome

This simple and cheap experiment has multiple outcomes. First, according to [1] it is possible to see the level of pollution of the snow and ice (soil). The fact that samples are spacially separated (time separation can be neglected thanks to the non-deterministic order of the samples) allows to map the level of pollution (measured as the level of eutrophication and of contamintants carried by macro and micro algae) with the density of the human population. For a previous analysis in literature see [7]. This result can be achieved on site during the data gathering.

A second aspect is the bacteria population. The fast bacteria identification algorithm described in [2] allows to classify zones of the sampled area on the basis of the bacteria presence. However, in the cited work the distinction between different bacteria is carried "empirically" and in an unclear way. The classification part can be substituted using a simple unsupervised classification algorithm, well known in the machine learning community. See for example [5]. A K-means clustering seems to be suitable for the purpose. Additional data about the bacteria can be obtained using the DNA sequencer. In this way it will be possible to assess both the hygienic level of the base (thus a quality-of-life assessment), what are the bacteria carried and how they are spread in the visited areas. Such information can be computed in very short time and it can be later be compared with historical data about the bacteria population such as the one in [3] so to obtain some information on the evolution of the bacteria in Antarctica. Finally, also data from the storm sensor can be used to understand the migration of the micro organisms.

The above two outcomes are in relative short times and should be considered as the main contribution of the experiment. However, additional results and conclusions can be thrown using the available dataset. The spectrometer is recognised as one of the fundamental tools for the analysis of the structure of the ice, that is one of the common data for climate change studies. Therefore, drilling can be considered as part of the sampling process. This will provide information about the effects of global warming and atmosphere pollution on the polar ice.

I.2 Contamination of the Samples

Contamination of the samples by sampler is one known issue of the scientific analysis. For this reason there are several procedures and protocols to minimize contamination of the material gathered. One example is [4]. Other includes examination of the recipient by lot, clean-dirty hand procedure and dust check of the apparatus. Where possible, the rover should implement and execute any of these procedures to ensure the reliability of the results.

I.3 Resource Allocation and Preparation

For this task are required few resources. Most of the data can be computed during the travel between on sample point and the other, since they are chosen randomly. Internet connection might be required occasionally to look up for scientific resources to interpret and elaborate the data. The necessary equipment is composed by a rugged (since the extreme conditions of the environment) laptop with enough computational power to run Matlab (to elaborate data), i5-i7 CPU and 8-16GB of RAM, and enough storage space to keep all the data gathered during the 30 days of the duration of the mission. Moreover, an additional Hard Disk can be used as backup. For the principal tasks, the on-board hardware of the rover is sufficient to carry the operations. If drilling is considered, the rover should be equipped with a drill and an appropriate storage area to hold the probes.

II. Task: Robotic Navigation and Test

For a roboticist is a seldom event to have the opportunity to experiment in such extreme environments. Since the author's background is in the aforementioned field he believes that a little effort should be put in the expedition to test various navigation and estimation algorithms that could be fundamental in such conditions.

The hostility of the climatic conditions and the roughness of the terrain can cause the failure of point-to-point GPS-based navigation. If the robot is equipped with a suitable laser sensor (or camera in case of clear view) and implementing a local path (or better, motion) planning algorithm will increase dramatically the chances of success of the mission, see for example [6].

Moreover, it would be interesting to implement a motion algorithm that considers both the IMU readings and the the power coming from the solar panels so to have motions optimized with respect to energy consumption.

Finally, logging sensor data will enable post-analysis of the motion producing a dataset suitable for state estimation for autonomous Unmanned Ground Vehicles (UGVs) in extreme environments.

III. Conclusions

In this document a cheap, low resources and simple experiment is explained. The description is kept general, without complete analysis of the details, both for lack of knowledge about the mission and for sake of brevity. With the described experiment it will be possible to measure the effects of the presence of human installation in a lab like environment. Additional information on the status of global pollution can be obtained by post-processing the data.

References

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