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3D photogrammetry of flooded mines and caves with the UX-1 series underwater exploration robots – The UNEXUP Project

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The UNEXUP project, funded under EIT Raw Materials, is a direct continuation of the Horizon 2020 UNEXMIN project. The aim of the project is to improve the original design of the UX-1 series robot prototypes (UX-1 a, b, c) built in the UNEXMIN project (2016-2019). Originally the effort was made to develop and test an innovative exploration technology for underground flooded mines cannot be obtained without high costs, or risks to human lives, in any other ways, and during the continuation, the main goal is to create market-ready robots and commercialize the technology.

The UX-1 series robots contain several different geoscientific instruments; a multispectral camera module, UV camera, gamma counter, water sampler, pH - EC measuring unit, fluxgate magnetometer and sub-bottom sonar. These instruments provide valid information about the water chemistry, the mineralogical and geological features of the explored mine during a dive. However, the use of this data requires the most accurate positioning and navigation possible, which robots also reveal to us using various tools: different short and long-range sonars and a so-called Structured Light Sensor (SLS) which provide a very detailed 3D point cloud. These complex and challenging navigational solutions are required to collect meaningful geospatial information for accessing not only safety conditions of the mines but, the primary focus the future economic potential of these mines if any. The occurrence and the orientation of mineralized rocks and structures (veins, faults, fractures, bedding) are imperative to understand for a successful new exploration program or reopening an old mine. The 3D underwater photogrammetry technique is of one the best currently available technologies that can provide such information for exploration companies.

The original UX-1 series robots have 5 built-in RGB cameras connected with simultaneously triggered light sources which also collect visual information from the underwater corridors. These images and videos can be used for photogrammetry. With the help of this technology, a 3D map can be built independently from the other navigational sensors. The difference of this technology

is that a visual image is accompanied by the 3D surface thus geological information can be seen and directly collected from such surfaces (more like a digital compass). Photogrammetry 3D surfaces are somewhat tighter, but contain larger amounts of data, i.e. denser point cloud compared to other sensors results. For this reason, it may be viable to restrict such surveys to geologically important and or more informative sites i.e. where 3D orientation of geological structures can be easily seen than measured. Furthermore, photogrammetry surveys require a slightly different way of navigation i.e. constant drifting along walls, hemispherical scanning of AOI, that is planned to be automated in future robotic missions. This technology was tested with the UX-1 series robots in a flooded underground mine shafts (Ecton) and underwater cave (Molnar Janos Cave) and resulted in good geological details in selected areas. In future upgrades of the photogrammetry system, we plan to improve the camera specification (geometry, field of view) and navigational requirements to obtain more continuous sections and semi- or fully- automated acquisitions.