Magnetic field measurement possibilities in flooded mines at 500 m depth

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ABSTRACT:

The main target of the UNEXMIN project is to develop a fully autonomous submersible robot (UX-1) which can map flooded underground mines, and also deliver information about the potential raw materials of the mines. There are ca. 30 000 abandoned mines in Europe, from which many of them still could hold significant reserves of raw materials. Many of these mines are nowadays flooded and the latest information about them could be more than 100 years old.

Although it is giving limited information, magnetic measurement methods, which detecting the local distortions of the Earth's magnetic field can be very useful to identify raw materials in the mines. The source of the magnetic field which is independent of any human events comes from the Earths own magnetic field. The strength of this field depends by the magnetic materials in the near environment of the investigated point. The ferromagnetic materials have powerful effect to influence the magnetic field. In the nature, iron containing minerals, magnetite and hematite have the most powerful effect usually. The magnetic measurement methods are rapid and affordable techniques in geophysical engineering practice.

For magnetic field strength and direction measurement FGM-1 sensors (manufactured by Speake & Co Llanfapley) were selected for the UX-1 robot. The sensor heads overall dimension are very small and their energy consumption is negligible. The FGM-1 sensor was placed and aligned in a plastic cylinder to ensure that the magnetic-axis aligned with the mechanical axis of the tube for more accurate measurement.

There are 3 pairs of FGM-1 sensors needed for the proper determination of the current magnetic field (strength and direction). The position of sensor pairs need to be perpendicular compared to each other. The 3 pairs of FGM-1 sensors generate an arbitrary position Cartesian coordinate system. We further developed / had installed temperature sensors to all FGM-1 probes, to compensate the temperature dependency even though it has small

effect. The UX-1 robot also contains the electronic block, which controls the three FGM-1 magnetic field sensor pairs, and store the measured data. The block contains the power module, the sensor interface modules with temperature compensation, the microcontroller module and the RS485 communication module also. The output data is a temperature compensated frequency value for each sensor pair.

The measured magnetic signal from the local XYZ coordinate system (local for the UX-1) should be converted to a universal coordinate system during post processing of the data. The exact position, facing and inclination of the robot must be known in the whole dive time to be able to do the above conversion. The measured magnetic signal will be placed into the measured mine map, reconstructed from the delivered 3D point cloud, thus the exact location of the magnetic anomalies can be identified.

Not much magnetic source is estimated in the operating environment of the robot, but its own generated magnetic noise can be significant. There will be many cooling fans, micro-controllers and multiple thrusters inside the pressure-hull of the UX-1, which generate magnetic field. The constant magnetic noise coming from the cooling fans can be compensated, but the varying fields caused by eg. the different thrusters's speed is problematic. We design a calibration method, where the effect of the main thrusters (even with changing speed) and the effect of the constant cooling fans could be compensated.

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