論文の内容の要旨

Dissertation Abstract

論文題目 Title: Intelligent multi resolution wide area seafloor observation using a landing AUV
（着底型 AUV を用いた広域海底の知的多重解像度調査手法の研究）

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Over the years, exploration of the seafloor has gained significant importance from scientific and economic point of view. Detailed surveys of hydrothermal vent fields have become necessary for better understanding of deep sea life. Areas rich with ferromanganese crusts have economic significance with potential scope of mining resources from the seafloor. Seafloor surveys are also essential for detection of radiation hotspots and chemical spills during disaster situations or underwater mine detection for harbor protection. Unmanned underwater vehicles have proven to be effective tools for performing such operations without the need of human presence inside the water. The areas that need to be covered for such surveys are often spread over few hundreds of kilometers. Cruising type autonomous underwater vehicles are usually deployed for wide area mapping of the seafloor from altitudes of few tens of meters and speeds of over a meter per second using acoustic sensors such as multi-beam sonar, side-scan sonar etc which offer a wide swath. At these speeds, using a lawn mower survey pattern, an AUV could cover a square kilometer area in about fifteen hours. These wide area maps have resolution of few tens of centimeters and can provide a general overview of the survey area but for detailed analysis, higher resolution information needs to be obtained from a variety of sensors. Hovering type underwater vehicles or remotely operated vehicles (ROV) are usually deployed for scanning the seafloor with high resolution from altitudes of a few meters and speeds of tens of centimeters per second using laser profiling or stereo vision systems. If scanning is performed using such systems over a large area, the vehicle would require sixty days to complete a one square kilometer area scan. To obtain further seafloor properties, sensors for in-situ analysis such as gamma radiation detectors, underwater microscope, Raman-spectroscopy are being developed by various groups. These sensors often require close proximity with the seafloor for integrated measurements or stable contact for obtaining reliable results. For this it is necessary for the vehicle to land on the seafloor which is also a time consuming operation. Due to limited ship survey time and high costs of operation, it is not possible to obtain high resolution information all throughout the survey area and deployment of different types of underwater vehicles is essential. Typical seafloor surveys involve wide area scanning using acoustic sensors from a cruising AUV and then manually analyzing this data for selecting areas for detailed observation based on the interest of survey. To overcome this problem, a new survey technique has been proposed for multi-resolution wide area seafloor observation using an autonomous underwater vehicle with ability to adapt the scanning resolution intelligently. In the proposed

method, an underwater vehicle can adapt its scanning resolution in real–time by analyzing the scanned bathymetry data during the survey and making appropriate decisions for fulfilling the survey interest. The survey interest is provided as a set of rules based on the property of the seafloor measured and the payload sensor used for observation.

In the proposed method, the vehicle scans a wide area of the seafloor using an acoustic sensor from a high altitude and fast speed to generate bathymetry with centimeter order grid resolution. The bathymetry data is then automatically analyzed in real–time using a suitable algorithm to identify seafloor features. Based on the survey rules and the features identified, potential areas for detailed high resolution scanning area identified where further information can be obtained from the seafloor. Waypoints are then automatically generated for efficiently scanning the selected area from a lower altitude and slower speed. High resolution bathymetry is obtained at these areas and analyzed to detect flat areas on the seafloor using an algorithm where the vehicle can potentially land. Along with flat areas, features on the seafloor are detected and their attributes are extracted. Based on the rules of the survey, the appropriate action to be taken is determined. If the survey requires the vehicle to land, a landing algorithm has been developed which detects suitable safe landing points where autonomous landing is performed. By changing the survey rules and the observation sensor, the proposed system can be adopted to surveying a variety of seafloor environments. To evaluate the proposed method, an autonomous underwater vehicle with specialized hardware and software to perform the proposed survey was designed and developed. Experiments were performed using this vehicle in a tank environment to analyze the performance of the system under different scenarios implemented using artificially created terrain. This research has provided a means for using underwater vehicles to perform complex autonomous surveys in different seafloor environments by generating multi–resolution maps and adapting the scanning resolution intelligently.