Underwater Search and Recovery

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INTRODUCTION

As human activities continue to expand into deep seas, such as the airline crashes of Air France 447 and Malaysia Airlines MH370, new challenges are arising for Underwater search and recovery [1]. Underwater Search and Recovery refers to the search, recovery, and salvage of objects with high value that are lost on the sea bottom. In order to perform the recovery operation, we need to know the position of the target object [2]. The MH370 Search had many lessons to be learned, as we may need to perform similar operations in the future. On 8 March 2014, MH370 lost contact with air traffic control [3]. over 3 million square kilometers were searched [4]. Mapping the MH370 search and transit area was only 1% of the Indian Ocean floor area and took over 2 years with the effort of one survey vessel. If we consider mapping the entire Indian ocean using the same pace and technology, it would take over 100 years to map [3]. So there's a need to develop some mathematical models to estimate the position of the target object with limited accuracy which can decrease our search area. This paper discusses the search operation and makes an attempt to discuss some parameters that could be required in building mathematical models for tracking the target. These mathematical models can be used in modeling and simulation to see how the target behaves under a wide range of conditions.

UNDERWATER SEARCH AND RECOVERY

Underwater Search and Recovery refers to the search, recovery, and salvage of objects with high value that are lost on the sea bottom [2]. The international efforts to locate the wreckage of

Malaysian Airlines flight MH 370, which went missing over the southern Indian Ocean. Till such time the debris and the black box is located, the cause of the accident will remain a mystery; but the unfortunate incident brought to fore the challenges posed by the underwater domain and also the national, regional, and global limitations of search and rescue [5]. Underwater Search & Recovery, is becoming critical, thus effective & efficient capability and capacity building are inescapable. It is important to appreciate that UWSAR is far more complex compared to the conventional SAR on the surface and therefore a very different set of acoustic capability & capacity building is necessary.

ACOUSTIC POSITIONING SYSTEMS

Acoustic positioning systems play a huge role in tracing the salvage object in search and recovery operations. Acoustic positioning systems measure positions relative to a framework of baseline stations, which must be deployed prior to operations. Acoustic positioning systems generally categorized into three broad types, Long baseline systems (LBL), Short baseline systems (SBL), Ultrashort Baseline systems (USBL), and the combinations of these systems can also be used as well [6]. The complexity of these systems increases with the depth at which we have to operate, as it requires a transponder or responder on the seafloor or on a Remotely operated vehicle (ROV). Modeling and Simulation for these systems is highly required to execute the plan as there's a need to rectify the errors, before moving on to the search operation. The rectification of errors in the plan is highly essential, as it had many complexities involved.

MODELING AND SIMULATION

The movement of the platform from the last known position until the actual search operation is initiated and beyond becomes important to plan the entire search operation. The platform has to be monitored until it settles down in a stable position in its final resting location. This monitoring

is undertaken using Modeling and Simulation that gets inputs on the oceanographic parameters to estimate the movement of the platform from the last known position.

SEARCH OPERATION

The complexity of the Underwater search increases with the depth at which we have to operate. Depending on the depth, the operation can be performed either by using divers or underwater vehicles. Search is classified into two types, Specific and Non-specific search. A Specific search is an attempt to locate a known object in a known area where it was believed to be lost even if the period is undefined, and the search terminates upon the location of the object. A Non-specific search is a search for either a type of object or anything valuable within the dive locale. Usually, the discovery of a relevant object does not terminate the search until the entire search area has been covered, or the search terminates early for other reasons [7].

To start with Specific search operations the last known position of the target object is required. In the case of Malaysia Airlines MH370, analysis of satellite communication between the aircraft and satellite communications network is used to determine the last known position [3]. And similarly, for ships and Cargo Automatic Identification Systems (AIS) data can be used.

Inputs on Underwater features are required to decide and finalize our search infrastructure. Inputs on Underwater features can be used to decide the methods or techniques for tracing the target object. search patterns like Expanding square search, Expanding Spiral search, Sector search, Contour search, parallel sweep search are normally used for tracing up to 2000 foot depth [8]. For higher depths, acoustic positioning systems like Ultrashort Baseline, Short Baseline, Long Baseline, Combined systems can be used while tracing the target Object [9]. After tracing the target, the recovery operation can be performed.

TRAJECTORY

Building the trajectory requires to quantify many unknowns (the last known position, the object type, and the wind, sea state, and currents affecting the object) to determine the motion of a drifting object on the sea surface [10], and also requires analysis of parameters, forces that can influence the motion of the target object into the sea. The trajectory of the target object is highly essential to determine the resting location of the object. The trajectory of the target may increase the probability of finding the target and can decrease the search area.

CHALLENGES

LAST KNOWN POSITION

In order to perform the search operation, we need to know the last known position of the target object. The Determination of the last known position of the target as a coordinate on the surface of the sea may not be possible in some cases (like in the case of MH370) due to loss of communication with the target. The last known position of the target is highly essential as they serve as initial conditions for mathematical models of trajectory.

DATA COLLECTION

In order to build the trajectory of the target, Inputs on underwater features are highly essential. Some of these inputs may not be readily available - To estimate some parameters (like density, salinity), may require the composition of waters of the site as they may influence the motion of the target.

ESTIMATION OF TRAJECTORY

- To estimate the trajectory of the target, the specifications of the target object like shape, size, mass are required. we also need to account for the deformations of the target, which is not possible.

- The target object may not be able to withstand pressures in the higher depths which may lead to further damage to the target.
- We may not be able to account for the water entered into the target due to wreckage.
- The target may collide with some sediments, which may deviate the path, and may lead to further damage to the target.

All these factors decrease the accuracy of the mathematical model of the trajectory of the target. It's impossible to determine the accurate path of the target object as we will never be able to account for some of the complications provided above.

TROPICAL LITTORAL CONDITIONS IN INDIAN OCEAN REGION (IOR)

The tropical littoral waters of the Indian Ocean region has many uncertainties like propagation from the medium that could corrupt the analysis findings. The tropical waters further display random fluctuations of the sea surface, varied bottom characteristics, and also a rich bio-diversity of the volume causing higher distortions to the signal of interest. The tropical littoral waters of the IOR present unique acoustic behavior that complicates the understanding of the undersea domain.

APPLICATIONS

SEARCH AND RESCUE

The mathematical models used for finding the trajectory of the target can also be used to search and rescue operations as well, but then it needs to consider the time span after the incident happened.

MARINE ARCHEOLOGY

Search for artifacts of historical interest and importance, and where applicable the recovery of such artifacts for study [7]. These artifacts can make a significant contribution to the knowledge of our past.

FORENSIC

Search for and recovery of material relevant to police investigations [7]. These data may further help the investigation and may provide a strong base.

RESEARCH DIRECTIONS

To build the trajectory of the target, we need to account for the motion of the target along the surface and also with the depth. To account for the motion of the target along the surface of the sea we need to quantify many unknowns (the object type, and the wind, sea state, and currents affecting the object) [10]. To account for the motion of the target along with the depth, we may need to quantify many unknowns (the object type, object specifications like shape, size, mass, currents affecting the object, pressures, bathymetry, sedimentation). The inputs like the composition of water are also required to calculate the forces on the target. The 3 Dimensional analysis of the forces on the target object will be useful to find the path followed by the target.

SEARCH PATTERNS

We need to increase the efficiency of existing search patterns by adding or finding some new logical concepts that can decrease the search area and can increase the probability of finding the target.

MODELING AND SIMULATION

Modeling and Simulation can be used in finding the last known position as a coordinate on the surface of the sea with the information of the last communications with target and some satellite imaging sources. The platform has to be monitored until it settles down in a stable position in its final resting location. This monitoring is undertaken using Modeling and Simulation that gets inputs on the oceanographic parameters to estimate the movement of the platform from the last known position. The model provides the framework and based on the platform and

oceanographic parameters fed to the model, extensive simulation is undertaken to generate possible movement of the platform. So, the mathematical models that are built for finding the trajectory of the target can be used in Modeling and Simulation to know how the target behaves and moves under various conditions.

ASSUMPTIONS

It is really important to make some assumptions to find the trajectory of the target object as we may not be able to account for the deformations, damages, and collisions. So there's a need to work on building some proper assumptions along with the accuracy of the model.

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