Underwater Manipulator a Review (Article analysis)

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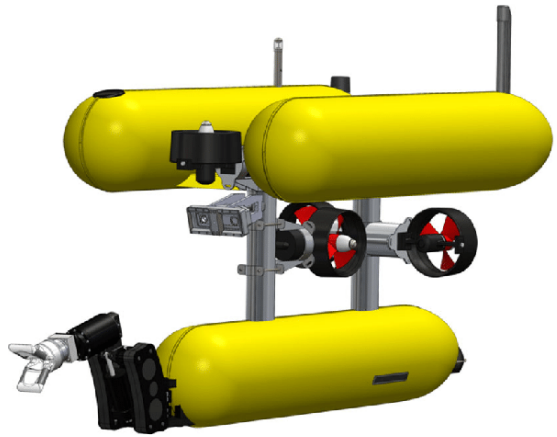
Where are use the underwater manipulators?

(a) ROV



(b) AUV

Figure: Subsea interventions.

What is necessary for the underwater manipulator?

Motion planning

Sensors

Mechanical design

Figure: Underwater manipulator.

Mechanical Design

Suitable material

Most common materials: titanium Ti 6-4, anodized aluminium alloys, stainless steel alloys and some plastics (Polyethylene).

Kinematics

It's similar to mechanical structure for the industrial robot arms and this kinematics can be applied to underwater manipulators.

Dynamics

Mechanical design defines the dynamic of underwater manipulator.

Which types can be the actuators for underwater manipulators?

(a) Electric-Ansaldo Maris 7080

(b) Hydraulic-Schilling Titan 4

Figure: Actuators.

Kinematic control and motion planning

Tools to avoid a collision with the environment.

An approach using Cartesian space teleoperation scheme.

Kinematic control and motion planning

Industrial robot arms use Cartesian space followed by inverse kinematics implementation and low level motion control.

Commercial underwater manipulators are teleoperated.

Kinematic control and motion planning

Genetic algorithms for obstacle avoidance (stationary and dynamic objects).

Global motion planning capable to generate feasible and obstacle free tasks path based on the 4D bump surface.

Kinematics redundancy.

Implementation Issues

Commercial underwater manipulators utilize point-to-point motion planning.

Nonlinearity comes with the use linear cylinder as the underwater manipulator actuator.

Low position accuracy in low level motion controllers of underwater manipulators.

Force Control

Use only position control scheme in manipulator can cause problems in planned trajectory.

Proposed a hybrid position/ force control scheme.

Motion Control

Depend of motion planning and sensors.

Decentralized Control

PID provide poor dynamic accuracy when trajectory tracking into play and the dynamic performance varies according to its configuration.

Centralized Control

Compensate nonlinearities by eliminating them rather reducing the effect by them and improve the trajectory tracking performance.

Neural and Fuzzy Control

Hybrid control method- integrate fuzzy control with neural network for resolving the nonlinear control without any knowledge of the underwater manipulator dynamics.

Teleoperation System

Rate control

Position control

Force feedback

Gripper control

Figure: Kraft master controller- Kraft TeleRobotics, Inc.

UVMS- Underwater Vehicle- Manipulator System

Even very skilled pilots are able to react the disturbance event has already happened, induces significant delays in the system.

Vehicle position set point can be replanned when the target is out of the workspace of the manipulator.

Advanced control when coupling effect are significant.

UVMS- Underwater Vehicle- Manipulator System

While manipulator is operating is to decouple the UVMS and run separate loop control to the base.

Automatic vehicle stabilization method.

Or using multiple small arms used as paddle to motion compensation.

Conclusion

Presented the advantages and disadvantages of different solutions in the underwater manipulators.

Machine vision it's a field to explore.

Major motion controlled automatically while the operator applying additional motion corrections.

Combined vehicle-manipulator control.

Bibliography

1. SIVČEV, Satja et al. Underwater manipulators: A review. Ocean Engineering, v. 163, p. 431-450, 2018.
2. ECA GROUP. Available: https://www.ecagroup.com/en/solutions/h1000-rov-remotely-operated-vehicle. Accessed in: April 02, 2020.
3. RESEARCHGATE. Available: https://www.researchgate.net/figure/Girona-500-AUV-with-the-4-DOFs-ECA-manipulator-equipped-with-a-custom-end-effector$_fig1_283339628$. *Accessed in : April 02, 2020.*

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