Underwater Manipulator Using Variable Buoyancy Actuators
IITM Technology Available for Licensing

Problem Statement

- The underwater robots are being employed for various operations at higher depths, where human reach is impossible in wide applications range from search & rescue, inspection & deployment of pipes, & underwater structures, sampling of the ocean & its resources, etc. Thereby, it is required underwater remotely operated vehicles which are equipped with manipulators. Manipulators are usually serially linked rigid arms with each arm individually actuated using electric or hydraulic motors. Sealing of motors to operate at higher depths is a **challenging task** & the system becomes **bulkier**. The existing underwater vehicles, variable buoyancy system/engine is an integral part designed along with other subsystems, having other issues.
- Hence there is a need to address the issues.

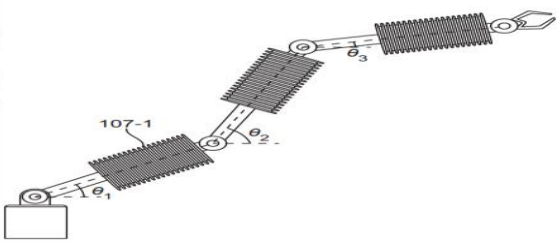
Technology Category/ Market

Technology: Underwater Manipulator;
Industry: Oil & Gas, Environment Engineering;
Applications: Extraction & mining, Robotics.
Market: The global underwater Robotics market is projected to grow at a **CAGR** of **10.8%** during **2024-2032.**

Technology

- Present invention describes an **underwater manipulator**.
- Said **manipulator** comprises at least one elongated **flexible structure** anchored at one end & **rotatable 360°** about the anchor point, & having an end effector at the other end.
- The flexible structure comprising a plurality of **arms** connected at pin joints, each arm configured to rotate within a plane to a predetermined angle, wherein each arm comprises:
- a **rigid link**; and
- a **variable buoyancy element** forming at least a portion of the length of the arm, & the variable buoyancy element configured with flexible bellows actuated using a linear actuator assembly.
- The variable buoyancy element is configured to vary buoyancy of the arm to cause a moment that results in motion of the arm in upward or downward direction.
- Further, the manipulator is configured to place the end effector at a 3-dimensional location within a predetermined radius of the elongated flexible structure.
- The pin passive joint is configured to restrict rotation of the arm to an **angle of rotation** ϴ which **ranges** between **0° to 90°.**
- The **linear actuator assembly** comprises a linear actuator piston operated using **hydraulic or electric means**.
- Further, a **method** of manipulating an underwater manipulator is described.

Fig.1



Intellectual Property

IITM IDF Ref. 1583; Patent No. 490423
PCT Application No: PCT/IN2018/050655

TRL (Technology Readiness Level)

TRL- 3/4, Proof of Concept ready, tested and validated in Laboratory

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Key Features / Value Proposition

❖ *Technical Perspective:*

❑ Standalone Unit:

- The **manipulator** is configured to be **a standalone and anchored to a base unit** on the **sea or ocean floor**.
- The arms of the manipulator are of **varying sizes** with **variable buoyancy elements** of capacity based on size of arm and with a **biggest link** placed **closest to the anchor point**.

❑ Manipulator:

- The manipulator is configured **to be an add-on** to **any autonomous underwater vehicle (AUV).**
- Each arm is configured to be **neutrally buoyant to reduce the load on the preceding arms**.
- The moment caused due to the actuation of the variable buoyancy element is either positive or negative based on the position of the **center of buoyancy (CoB)** with respect to the **center of gravity (CoG)** along the axis of the manipulator.
- The **manipulator** is configured with an **encoder** to provide **feedback** including angle of orientation of each link and the depth at which the variable buoyancy element is placed.

❖ *Industrial Perspective:*

1. The standalone device is **cost-effective & reliable**.
2. The efficient underwater manipulator is easily anchored to a base unit on any **sea or ocean floor**.

Images

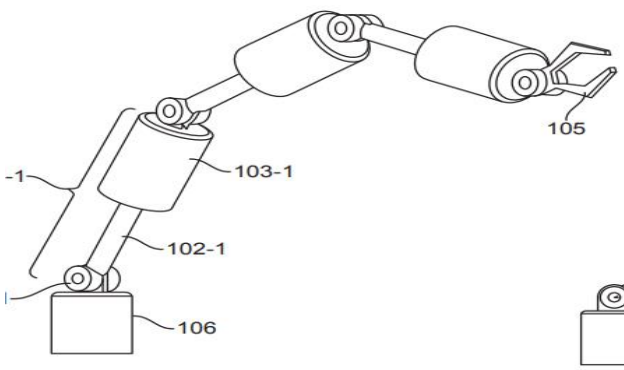

FIG. 1A

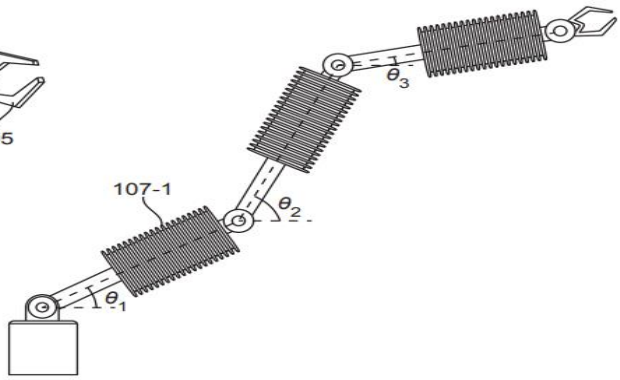

FIG. 1B

FIG.1A: Illustrates underwater manipulator configuration & FIG.1B: Illustrates a threelink manipulator actuated by variable buoyancy modules based on axially flexible metallic bellows.

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