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Design of a Thrust Vectoring System for an Underwater ROV

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Abstract : Underwater remote-operated vehicles (ROVs) are highly useful in aquatic research and underwater operations. Unfortunately, unsteady and unpredictable conditions underwater make it difficult for underwater vehicles to maintain a steady attitude during motion. Existing underwater vehicles make use of multiple thrusters positioned at specific positions on their frame to maintain a certain pose. This study proposes an alternate way of maintaining a steady attitude during horizontal motion at low speeds by making use of a thrust vector-controlled propulsion system. The study began by carrying out some preliminary calculations to get an idea of a suitable shape and form factor. Flow simulations were carried out to ensure that enough thrust could be generated to move the system. Using the Lagrangian approach, a mathematical system was developed for the ROV, and this model was used to design a control system. A PID controller was selected for the control system. However, after tuning, it was realized that a PD controller satisfied the design specifications. The designed control system produced an overshoot of 6.72%, with a settling time of 0.192s. To achieve the effect of thrust vectoring, an inverse kinematics synthesis was carried out to determine what angle the actuators need to move to. After building the system, intermittent angular displacements of 10°, 15°, and 20° were given during bench testing, and the response of the control system as well as the servo motor angle was plotted. The final design was able to move in water but was not able to handle large angular displacements as a result of the small angle approximation used in the mathematical model.

Keywords : PID control, thrust vectoring, parallel manipulators, ROV, underwater, attitude control
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