STABILITY ANALYSIS OF A SMALL SCALE REMOTELY OPERATED UNDERWATER GLIDER

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Specially dedicated to my beloved family (Nur Safiyah and Muhamad Fayyadh Alqushayyi) and those who encouraged, helped, guided and inspired me throughout my journey of education

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ABSTRACT

The conventional process of maintaining underwater depth level for Unmanned Underwater Vehicles (UUVs) requires an operator to have a high skill and experience. Therefore, it is an important assessment to develop an automatic control scheme for underwater depth level control system and fabricate an underwater vehicle's prototype body as a test-bed to implement and study the performance of control scheme. Hence, the purposes of this research are to design, model and fabricate a prototype body of a Remotely Operated underwater Glider (ROG) and analyze stability equilibrium of the new glider design. This research also attempts to develop a programmable ON/OFF control scheme for the underwater depth level control system and study the performance of the control scheme by experimental verification and trials. The ROG is modelled based on the SLOCUM glider and Seaglider designs using SolidWork and MAXSURF HYDROMAX is employed to calculate the stability equilibrium. The collected real time data are analyzed using the MATLAB System Identification Toolbox^{TM} to verify the ROG's net weight-depth system. As a conclusion, the ROG has a cylindrical body shape and the stability calculation shows that the ROG is at stable equilibrium state when heeling from 0° to 45° and at unstable equilibrium state when heeling started from 100° to 170°. In addition, the widest heeling range of stable equilibrium is that of ROG and followed by Seaglider and SLOCUM glider. Results of the analysis show that the average rise time, settling time and overshoot for the ROG tested in a swimming pool are 2.67 s, 117.33 s and 17.69% respectively. Meanwhile, the average rise time, settling time and overshoot for the ROG tested at sea are 1.33 s, 233.33 s and 43%. Hence, the ROG can serve as a baseline stage for open water operations and multivehicle exploitation.

ABSTRAK

Proses konvensional mengekalkan tahap kedalaman Kenderaan Bawah Air Tanpa Pemandu (UUVs) memerlukan pengendali mempunyai suatu kemahiran dan pengalaman yang tinggi. Oleh itu, penting untuk membangunkan skim kawalan automatik untuk sistem kawalan tahap kedalaman dan menghasilkan prototaip badan kenderaan bawah air sebagai tapak ujian untuk melaksanakan dan mengkaji prestasi skim kawalan. Oleh itu, tujuan kajian ini adalah untuk mereka bentuk, model dan reka badan prototaip Kenderaan Kawalan Peluncur di dalam air (ROG) dan menganalisis keseimbangan kestabilan reka bentuk baru. Kajian ini juga bertujuan membangunkan satu skim kawalan *ON/OFF* untuk sistem kawalan tahap kedalaman air dan mengkaji prestasi skim kawalan oleh pengesahan eksperimen dan ujian. ROG dimodelkan berdasarkan reka bentuk *SLOCUM* dan Seaglider menggunakan *SolidWork* dan MAXSURF HYDROMAX digunakan untuk mengira keseimbangan kestabilan. Data masa sebenar dianalisis menggunakan *MATLAB System Identification Toolbox*^{TM} untuk mengesahkan sistem berat bersih-kedalaman ROG. Kesimpulannya, ROG mempunyai bentuk badan silinder dan pengiraan kestabilan menunjukkan bahawa ROG adalah pada keadaan keseimbangan stabil apabila kecondongan pada 0° hingga 45° dan pada keadaan keseimbangan tidak stabil apabila kecondongan bermula pada 100° hingga 170°. Di samping itu, keseimbangan stabil terluas ialah ROG dan diikuti oleh Seaglider dan *SLOCUM*. Keputusan analisis menunjukkan bahawa masa naik purata, masa penetapan dan terlajak untuk ROG yang diuji dalam kolam renang adalah 2.67 s, 117.33 s dan 17.69% masing-masing. Sementara itu, kenaikan masa purata, masa penetapan dan terlajak untuk ROG diuji yang di laut adalah 1.33 s, 233.33 s dan 43%. Oleh itu, ROG boleh berfungsi sebagai peringkat asas untuk operasi air terbuka dan pelbagai kenderaan eksploitasi.