# FORCE CONTROL USING PREDICTIVE FUNCTIONAL CONTROL (PFC) ALGORITHM FOR TWO CHAMBERS SOFT ACTUATOR

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This project is dedicated to my beloved mother Haj. Nafisa Habib, father Alh. Kabir.M. Dankadai, my brothers my sisters and Rabi’u Kwankwaso for their encouragement and blessing, support and caring.

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# ABSTRACT

The current trend in the world of automation and robotics heavily applies metal structure type of the actuators which are heavy, rigid, difficult and expensive to develop. Other areas of applications like medical, agriculture, biological and welfare requires less rigid and safer robots. Thus, a biologically inspired robot is required to meet this certain criteria. This lead to the recent attraction in the study and development of Pneumatic Soft Actuator (PSA) because it has more advantages over hard actuators to suit the applications mentioned above due to its simple structure, low cost, high efficiency, high compliance, high power to weight ratio and ensures safe and more natural way of interaction. Despite the advantages of pneumatic soft actuator it has nonlinearity and hysteresis, which makes them difficult to model and control. The main objective of this study was to obtain mathematical model and control the force of a two chamber pneumatic soft actuator. Obtaining nonlinear mathematical model accurately to be used in controller design needs to determine all physical parameters of the real system which is very expensive and time consuming, to simplifying this procedure, model of system was analysed and obtained using system identification toolbox in MATLAB software. Input and output data was acquired from an experimental setup which was used to obtain a transfer function force model of the system. The best model was accepted based on the best fit criterion through SI toolbox. Predictive Functional Controller (PFC) was designed and simulated for the model via MATLAB/Simulink. The results showed that PFC controller provides better output than a conventional PID controller when tested using several references. PFC controller exhibits faster response to the system with desired transient error. The study represented in this project can be further broaden by taken position control into account and validation of the simulated control can be done on the experimental setup.

# ABSTRAK

Trend semasa di dalam dunia automasi dan robotik banyak bergantung kepada jenis penggerak dari struktur logam yang berat, tegar, mahal dan sukar untuk dibangunkan. Antara bidang lain yang menggunakan aplikasi ini adalah seperti perubatan, pertanian, biologi dan kebajikan yang memerlukan robot yang kurang tegar dan lebih selamat. Oleh itu, sebuah robot yang berinspirasikan biologi diperlukan untuk memenuhi kriteria yang tertentu. Hal ini membawa kepada tarikan terbaru dalam kajian dan pembangunan penggerak pneumatik lembut kerana ia mempunyai banyak kebaikan berbanding penggerak kasar untuk disesuaikan dengan aplikasi yang disebutkan di atas kerana ia mempunyai struktur yang mudah, kos rendah, kecekapan tinggi, pematuhan yang tinggi, kuasa tinggi kepada nisbah berat dan menjamin keselamatan serta interaksi yang lebih semula jadi. Walaupun penggerak pneumatik lembut mempunyai pelbagai kebaikan, namun sifatnya yang tidak linear dan histerisis, menjadikan ianya sukar untuk dimodel dan dikawal. Objektif utama kajian ini adalah untuk mendapatkan model matematik dan mengawal daya pada sebuah penggerak pneumatik lembut yang mempunyai dua kebuk. Data bagi masukan dan keluaran diperolehi daripada eksperimen yang dijalankan dan ianya digunakan untuk medapatkan model persamaan daya bagi sistem ini. Model terbaik yang diterima adalah berdasarkan kepada kriteria sesuai yang terbaik melalui kelengkapan pengenalan sistem (SI Toolbox). Pengawal fungsi ramalan (PFC) telah direkabentuk dan model telah disimulasikan dengan menggunakan perisian MATLAB/SIMULINK. Hasil kajian menunjukkan pengawal PFC mampu menyediakan keluaran yang lebih baik berbanding pengawal PID konvensional apabila diuji dengan beberapa rujukan.