



**UNIVERSITI PUTRA MALAYSIA**

**DEVELOPMENT OF A CRISP FUZZY-LIKE CONTROLLER USING  
FORMULA-BASED AND VECTORIZED APPROACHES**

**MOHAMMAD KARIMADINI.**

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**Chairman: Mohammad Hamiruce Marhaban, PhD**

**Faculty: Engineering**

Simplifying of implementation of linear state feedback fuzzy controllers is investigated through the thesis. One of the most important problems in fuzzy controller design is the number of fuzzy subsets (membership functions) for each fuzzy input/output variable. The number of fuzzy subsets and consequently the number of fuzzy rules should be big enough to achieve good approximation of control surface and have a smooth and robust control. However as the number of rules increases, the memory space, and program cycle time and total project cost will also increase dramatically.

The thesis proposes crisp-fuzzy like controller derived by two novel approaches. The first one which is formula based crisp fuzzy-like controller proves that the monotonic fuzzy controller is similar to nonlinear saturated controller and then represents several different controller formulas. The second controller namely vectorized crisp fuzzy –like controller maps the fuzzy variables in a vectorial space and derives formula that has the structure similar to PID controllers. The proposed controllers are inspired from fuzzy



logic where they can express the control law semantically but they are absolutely crisp. Consequently the needed memory space is minimized since the rule table has been replaced with the formula. On the other hand fuzzy controllers have high computational complexity while the new controllers are very simple to design, tune and implement. Some new performance indexes also are proposed to evaluate the performance and stability of different controllers. Several well-known industrial models are used for simulation and a dimmer circuit to control the bulb temperature, has been used as a case study. Both simulation and experimental results show that the crisp fuzzy-like controllers have the same or in some cases better performance and stability compared with the conventional fuzzy logic controllers, with extra merits of lower memory space and cycle time.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Master Sains

**PENGAWAL SEAKAN SAMAR YANG JITU BERDASARKAN FORMULA  
DAN PENDEKATAN PEMVEKTORAN**

Oleh

**MOHAMMAD KARIMADINI**

**Mei 2006**

**Pengerusi: Mohammad Hamiruce Marhaban, PhD**

**Fakulti: Kejuruteraan**

Memperudahkan pelaksanaan pengawal samar suapbalik keadaan lurus adalah dikaji selidik melalui tesis ini. Salah satu daripada masalah penting di dalam rekabentuk pengawal samar adalah bilangan subset-subset samar (fungsi-fungsi keahlian) untuk setiap pembolehubah input/output samar. Bilangan subset samar dan seterusnya bilangan aturan samar mestilah besar dan mencukupi bagi mencapai anggaran permukaan kawalan yang baik dan mempunyai kawalan yang lancar dan berdaya tahan. Namun demikian, penambahan bilangan aturan telah menyebabkan penambahan secara mendadak terhadap ruang memori, masa kitaran pentaturcaraan dan jumlah kos projek

Tesis ini mencadangkan pengawal seakan-samar jitu yang dihasilkan dari dua pendekatan yang novel. Yang pertama iaitu pengawal seakan-samar jitu berasaskan formula membuktikan bahawa pengawal samar yang bersifat monotonik adalah serupa dengan pengawal tepu lurus dan seterusnya mewakili beberapa formula pengawal yang berlainan. Pengawal yang kedua iaitu pengawal seakan-samar jitu yang bervektor, memetai pembolehubah samar di dalam ruang vector dan menghasilkan formula yang mempunyai struktur serupa dengan pengawal PID. Pengawal-pengawal yang



dicadangkan adalah diinspirasikan dari logik samar tetapi mereka adalah jitu dimana mereka mampu mempersembahkan aturan pengawal secara semantik. Seterusnya ruang memori yang diperlukan adalah dikurangkan oleh kerana jadual aturan telah digantikan dengan formula. Sebaliknya, pengawal samar mempunyai kerumitan linguistik berkomputer yang tinggi, manakala pengawal yang baru adalah amat mudah untuk merekabentuk, tiun dan melaksana. Beberapa indeks pencapaian baru juga dicadangkan bagi menilai prestasi dan kestabilan pelbagai pengawal. Beberapa model-model industri yang mayshur digunakan dalam simulasi dan litar pemalap untuk mengawal suhu buih telah digunakan sebagai pembelajaran kes. Kedua-duanya, simulasi dan keputusan eksperimen menunjukkan bahawa pengawal seakan-samar jitu mempunyai prestasi dan kestabilan yang sama atau di dalam kes-kes yang tertentu lebih baik jika dibandingkan dengan pengawal logic samar konvensional, dengan kelebihan mempunyai ruang memori yang kecil dan masa kitaran yang kurang.

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First and foremost, I would like to express my gratitude to Allah, for giving free will and strength to complete my project.

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My special thanks to the members of engineering faculty and GSO of Universiti Putra Malaysia for their helps.

My greatest thanks go to my mother and my deceased father how always have encouraged and believed in me. Thanks all my brothers, sisters, parents in law and entire family. My final thanks are for my wife and my sons the source of my inspiration.

Peace and blessing upon prophet Mohammad (s.t.w.).





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