近五年內主要研究成果說明

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快速連結

1. 主要研究成果

近五年內主要研究成果分佈於下述 (1)-(4) 項，請參酌。其餘為多年累積成果。

1. 持續關注在寬鬆條件 (relaxation) 的鬆綁並擴展至非共同 P(Non-PDC) 求解問題 (feasibility)。目前方向有
   (1) 將 SOS 與 LMI 結合找出更寬鬆的穩定解目前正在審查中 [1]。
   (2) 將齊次多項式理論 (homogeneous polynomial theory) 應用於觀測器與控制器，並證明分離定理 (principal of separation) 仍然適用 [2, 3]。
   (3) 探討多項式系統 ($\dot{x} = f(x) + g(x)u$) 的穩定性問題。與國外學者合作，共同發表 [4]。
2. 今年九月新書發表 [5] "LaTeX& U 自助出版" ISBN978-957-41-9448-3。
3. 最近兩年除學術研究外，仍致力於大學用書撰寫，目前一本電路及電子學 [6] 已完成並有國際標準書碼 ISBN978-957-41-8721-8; 另一本自動控制 [7] 已通過中央大學出版中心推薦，目前正在最後修飾，國際標準書碼 ISBN 尚未申請。
4. 線性矩陣不等式 (LMI) 雖方便求解控制問題，更好的求解方法亦不斷更新，目前研究著重於了解 LMI 與 SOS 的差異 -- 平方和求解 [8, 9, 10, 11, 12]。
5. 強調以各種方法的寬鬆條件 (relaxations) 結合線性矩陣不等式 (LMI) 求解 [13, 14, 15, 16, 17, 18] 以除去保守性。目前研究成果顯示 [13] 的數學模式能涵蓋過去多年多人的研發成果。
6. 應用線性矩陣不等式 (LMI) 求解時常因其保守並成為缺點，因此如何除去保守性 (conservatism) 尋找較寬鬆的求解方法 (relaxation methods)[19, 20, 21]。
7. 消耗性控制 (dissipative control) 應用於模糊系統穩定性問題 [22, 23, 24, 25]。
8. 運用系統定理 (circle criterion, Popov criterion) 研究非線性系統輸入飽合 (input saturation) 問題 [24, 26, 27, 28, 29, 30, 31]。
9. 探討模糊取樣系統 (fuzzy sampled-data systems) 穩定性問題 [32, 33]
10. 探討模糊 LFT 系統與強健模糊系統的關係並探討最佳性能 [34, 35, 36, 37, 38]。
11. 探討非線性系統與強健模糊系統的關係並探討最佳性能 [39, 40, 41, 42]。
12. 非二次穩定 (non-quadratic stability) 及具常數之模糊模型 (affine T-S)[43, 44, 45, 46, 47]。
13. 強健理論 (robustness)，最佳化 (optimization) 及干擾衰減理論 (noise attenuation) 與模糊控制系統 (Takagi-Sugeno fuzzy model) 結合。
    (a) 研究不同控制器間的強健 H_∞ 控制方法 [48, 49, 50, 51, 52, 53]。(b) 研究模糊系統 H_2 性能針對不同控制器參數的最佳解問題 [54, 55, 56, 57]。
    (c) 研究混合 H_2/H_∞ 性能動態輸出回饋控制器的設計 [58, 59, 60]。
14. 考慮具延遲現象的模糊濾波器設計 [61, 62, 63, 64]。
15. 將模糊控制理論應用於模糊濾波器的設計，系統延遲問題並考慮濾波器 H_2/H_∞ 性能 [65, 66, 67, 68, 69, 70, 71, 72]。
16. 文獻 [73] 著重於非線性控制理論的分析與推導，對非線性系統之控制與估測，結合線性系統的觀念與技巧，推導出非線性控制法則。其模擬結果並與線性方法做比較，驗證本法正確。
17. 模糊理論/控制經多年的發展已漸獲注意，然模糊規則數太多，以致電腦計算費時。為此，有些研究重心則漸漸偏向『如何將模糊規則數減少』；[74] 是針對倒單擺，應用模糊控制，以滑動模式控制法如何將模糊規則數減少提出研究心得 [75, 76]。則是將適應性控制理論應用於倒單擺以增加自我學習 (self-learning) 功能。
18. 文獻 [77] 則是運用誤差回饋觀念於模糊系統辨識，提出一規則數少且有效率之演算法。另有模糊建模的相關研究成果 [78, 79]。
19. 將強健控制中之多項式理論 --Kharitonov Theorem 及 Hermite-Biehler 定理 --應用於模糊系統的 Takagi-Sugeno 模式進而找出使其穩定之充分條件 [80, 81, 82, 83, 84, 85]。
20. 將多項式理論中最重要的卡利定理 (Kharitonov Theorem) 以新法證明並統一證明技巧於卡利定理所延伸之定理 (e.g. 16-plant theorem, 32-edge theorem)[86, 87, 88]。
21. 多項式理論中尋找不確定系統的參數變化範圍，以確保系統穩定；[89, 90, 91] 則分別找出較目前文獻中更大的穩定區域 (robustness margin)。

2. 持續性著作

近年來主要研究領域為探討強健控制與模糊 Takagi-Sugeno 系統間的關係，期望尋找決定模糊系統穩定與否的系統化分析方法。多年的研究心得已有持續性的成果，簡述如下：

1. 探討 LMI 與 SOS 的結合 [3, 2, 1, 4]，再尋求擴大穩定空間；目前著力於平方和求解 [8, 9, 10, 11, 12]。試圖探討多項式系統 ($\dot{x} = f(x) + g(x)u$) 的穩定性問題。
2. 兩年多來致力於大學用書撰寫 [6, 7, 5]。研究工作仍持續進行。
3. 寬鬆條件求解之持續性著作 [16, 17, 18, 19, 20,

21]。

4. 消耗性控制 (dissipative control) 整合定理之持續性著作 [22, 23, 24, 25]。
5. Lyapunov 整合定理 [30].
6. 線性理論中有關系統定理 (circle criterion, Popov criterion) 與強健模糊控制的結合的連續性著作 [26]-[31]。
7. 有些非線性架構具有分式項，此時需借由線性分式轉換 (linear fractional transformation, LFT) 轉換至 LFT 系統。[34]-[38] 是 LFT 的連續性著作。
8. 將最佳化及干擾衰減理論與模糊控制結合，研究 Riccati 方程式與 LMI 不等式的關係。以上 3)-6) 項可視為有關強健理論及模糊控制的持續性著作。
9. 研究模糊濾波器的設計，系統延遲問題 [72, 61, 62, 63, 64]。
10. 吾人將多項式理論與切換控制器運作原理結合，發展出有別於的模糊控制理論：稱之為『模糊系統切換控制』。著作 [80]-[85] 可視為有關多項式理論與模糊控制的持續性著作。
11. 對多項式理論 (polynomial theory) 亦有研究心得。著作 [86]-[91] 則可視為有關多項式理論的持續性著作。
12. 有關適應性滑動模糊控制的持續性著作 [74, 75, 76]。
13. 此外，有關模糊系統辨識，涉獵基因演算及類神經架構的持續性著作 [77, 78, 79]。

3. 未來研究計畫

近五年來投注於人工智慧的分析與研究，著重在模糊控制 (fuzzy control)，模糊觀測與濾波，模糊建模 (fuzzy modeling)，近幾年亦興趣於線性強健控制，及多項式理論。除上列各項外，目前已將今年的研究心得撰寫投稿於相關領域 (見 [3, 2, 1, 4])，深信研究成果將持續進展下去。尤其是系統理論，強健理論，與模糊控制的關係，三者間之差異為何? 如何結合? 這些皆是有趣的研究主題，本人深信目前研究方法正確 --勤讀研究論文，熟悉研究工具 --具體研究方向如下：

1. 目前正全心投入 LMI 與平方和 (SOS) 方法，深信不久即可証明 SOS 充份且必要的完整解。並將這些理論用於非共同 P 求解問題。
2. 持續關注於大學用書 [6, 7, 5] 今後之修訂工作，期望有助控制與電機領域學生學習相關領域。
3. 尋找較寬鬆的求解方法 (relaxation methods)，找出充份且必要的完整解 (exact solution)。目前研究成果 [12, 16, 20] 提供了具體的初步成果，且完整解 [13] 最近已獲 IET 期刊接受，其數學模式能涵蓋過去多年/多人的研發成果。故研究方法正確，將來仍有發展空間。
4. 至今許多文獻有關模糊系統控制，估測或濾波器的設計皆有相當的研究成果發表。然而這些成果皆以共同 P 的線性矩陣不等式之方法呈現，其解空間受到限制為該法之缺點，故有許多改善空間值的研究。持續尋找較寬鬆的求解方法 (relaxation methods)，因為充份條件往往保守，尋找較寬鬆的求解方法其影響深遠。
5. 因電腦的快速成長控制機構 (analog controller) 已漸漸由數位控制 (digital controller) 所取代，因此連續系統與離散控制器的結合成為混合系統 (hybrid systems, sampled-data systems)，與此相對的混合模糊系統是否可行，成為研究題目。
6. 線性理論中有關系統定理 (system theories) 與強健模糊控制的連結，了解並擴大系統定理的應用。
7. 強健理論，最佳化及干擾衰減理論與模糊控制結合。各種控制器如"狀態回授控制器"，"輸出回授控制器"，"動態輸出回授控制器"，"觀測器" 等設計皆為值得研究的題目。
8. 強健控制中多線性結構與模糊系統 T-S 結構間如何銜接，目前成果顯示值得深入探討：許多多線性結構的分析值得學習研究。

4. 經歷與榮譽

1. 99，100 年公務人員特種考試機械組命題及閱卷委員。
2. Visting scholar at Electrical Engineering of Stanford University, CA, USA, Spring, 2009.
3. Session Chair/Cochair of
   2011 Fuzzy Systems and Control I and II, FUZZ-IEEE 2011, Taipei, Taiwan.
   2010 Fuzzy Systems and Control II, IEEE Multi-Conference on Systems and Control, Yokohama, Japan.
   2009 Fuzzy System and Control II, FUZZ-IEEE 2009, Jeju, Korea.
   2008 Fuzzy Theory and its Applications Conference.
   2007 Chinese Automatic Control Conference
4. Member of Tech. Program Committee in
   2009 International Symposium on Intelligent Control (ISIC)
   2006 IEEE Int'l Conf. on Systems, Man and Cybernetics.
5. 國際期刊論文審查委員。
   IEEE Transaction of Fuzzy Systems
   IEEE Systems Man and Cybernetics
   Fuzzy Set and Systems
   IET Control Theory and Applications
   Aisa Journal of Control

Automatica
Int'l Journal of Approximate Reasoning
Int'l Journal of Adaptive Control and Signal Processing
J. of Optimal Control Applications and Methods

6. 國內外研討會論文審查委員。
7. 國科會學術計畫初審委員 (2002-2008, 2010-2012)。
8. 國科會 96 學年控制學門" 控制理論研究" 規畫委員 (2008)。
   國科會 93 學年控制學門" 控制理論研究" 規畫委員 (2004)。
9. 博士班林銘隆先生 (已畢業) 榮獲 2002 年『第十屆模糊理論及其應用會議』學生論文英文演說競賽第三名 [45]。

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