十二、研究計畫內容：

（一）近五年之研究計畫內容與主要研究成果說明。（連續性計畫應同時檢附上年度研究進度報告）

我們的研究主要重於理論與實務並行，不同於其他國際學術團隊的研究，我們的目標是將尖端的學術研究導入產品應用實務，從 2008 年開始，累計國際學術論文超過 **20 篇** (其中包含 7 篇 IEEE 一級學術期刊和 10 篇優良會議論文)，專利申請超過 **60 件**，包含台灣、美國、大陸和歐洲 (2012 年**獲准美國專利**高達 **8 件**)，關鍵核心技術移轉給宏碁科技和奇美電子 **15 件**，技術移轉金高達 **500 萬**以上，擔任國科會計畫主持人 **3 件** (其中包含國科會**優秀年輕學者研究計畫**)，教育部課程改進計畫主持人 **2 件**，產學合作案 **8 件**，擔任銓晟科技、傑飛特科技、泓科科技雲端技術顧問累計 **3 間**，行政院勞委會職訓局諮詢專家 1 次，榮獲 ACM 台灣分會與中華民國資訊學會所頒發的**李國鼎青年研究獎 (主要貢獻: 嵌入式多媒體)**，帶領學生參加國內外比賽得名 **8 件**，指導研究生獲得**最佳論文獎 3 件**(分別為台灣電機電子工程學會最佳碩士論文優等獎、中華民國民生電子學會碩博士論文獎、中華民國資訊學會最佳碩士論文獎)，我也於 2011 年 2 月受邀到紐西蘭梅西大學舉行**兩場**重要性的演講，足見研發成果已受到國際肯定。

我在多媒體系統技術研究成果，主要有四個主題「高品質的多媒體無線網路傳輸系統」、「自動化視訊監控系統」、「數位視訊壓縮技術實作」與「高畫質數位影像增強技術用於顯示器智能背光控制」，研究成果有 10 篇優良國際期刊(其中 IEEE 包含 7 篇 IEEE 一級學術期刊) [1]-[10] 以及 10 篇優良會議論文[10]-[19]，技術移轉累計 15 件，技術移轉金高達 500 萬以上，重要美國專利超過 21 項[20]-[39]。其中「高畫質數位影像增強技術用於顯示器智能背光控制」軟體演算法實踐方面已刊登在 **IEEE Transactions on Image Processing (Ranking: 16/244=6%)**、**IEEE Journal of Display Technology (Ranking: 13/125=10%)**和 **Elsevier Engineering Applications of Artificial Intelligence (Ranking: 10/90=11%)**頂級國際期刊上，且已經將相關技轉給奇美電子，技轉金額為 73 萬，並有 2 項美國專利與中華民國專利，奇美電子在新一代數位面板中也採用我們的影像增強技術，也將為奇美的數位面板顯示器帶來以往未有的影像品質，有助於台灣產業升級，預估此技術將為奇美電子創造超過 5000 萬的產值，在「高畫質數位顯示器增強結合背光控制技術」學術成果方面，目前已接受刊登在頂尖的學術期刊論文有：

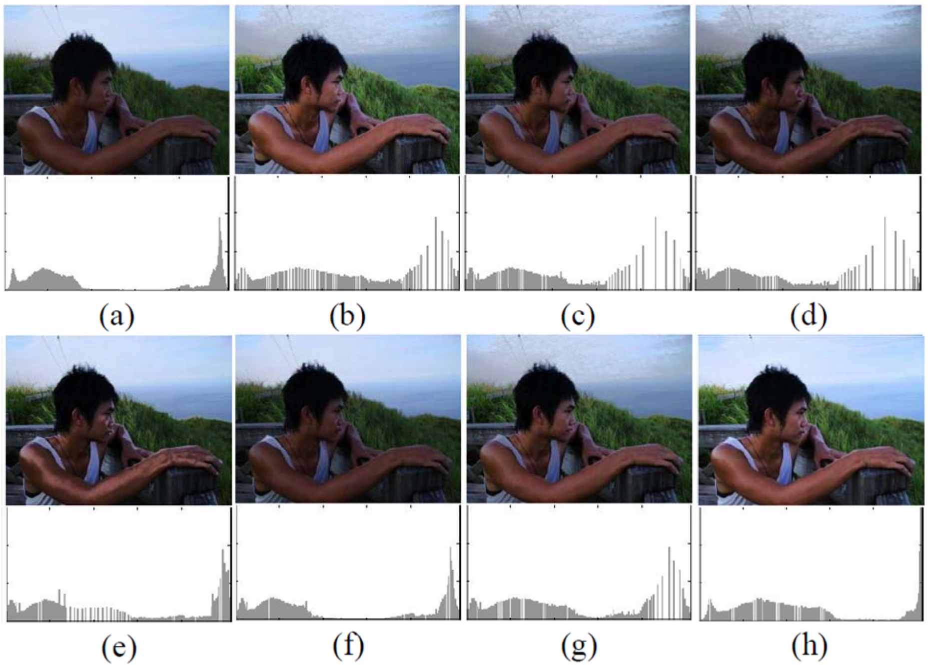
- **Shih-Chia Huang,** Fan-Chieh Cheng, and Yi-Sheng Chiu, "Efficient Contrast Enhancement Using Adaptive Gamma Correction with Weighting Distribution," *IEEE Transactions on Image Processing*, 2013 (Ranking: 16/244=6%)
- Fan-Chieh Cheng, and **Shih-Chia Huang**, " Efficient Histogram Modification Using Bilateral Bezier Curve for the Contrast Enhancement," *Journal of Display Technology*,2013 (Ranking: 13/125=10%)
- **Shih-Chia Huang**, and Chien-Hui Yeh, " **Image Contrast Enhancement for Preserving Mean Brightness without Losing Image Features,** " *Elsevier Engineering Applications of Artificial*

Intelligence, 2013 (Ranking: 10/90=11%)

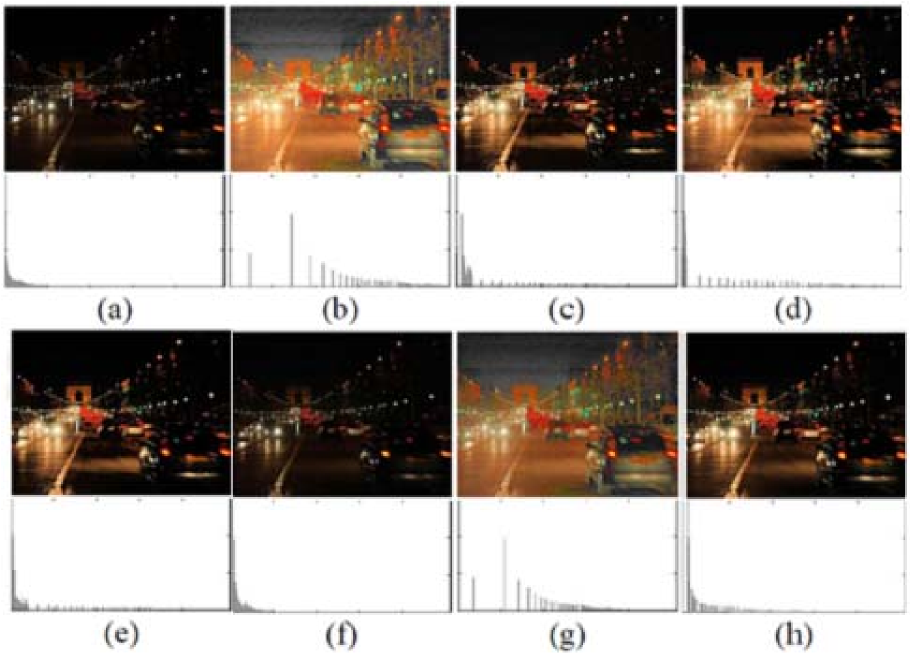
- Yi-Sheng Chi, Fan-Chieh Cheng, and **Shih-Chia Huang**, " Efficient Contrast Enhancement Using Adaptive Gamma Correction and Cumulative Intensity Distribution, " *IEEE International Conterence on Systems*, Man, and Cybernetics, 2011
- Wen-Chieh Chen, **Shih-Chia Huang**, and Trong-Yen Lee "An efficient Reconfigurable Architecture Design and Implementation of Image," *IEEE International Conference on High Performance Computing and Communications*, 2012

現階段「高畫質數位影像增強技術用於顯示器智能背光控制」已具體的實踐高畫質靜態影像上在奇美現顯示器上(如圖一所示)，我們的影像增強演算法增強效果優於其他現有影像增強技術，也已經過奇美電子嚴謹的產品驗證，研究結果將發表於**IEEE Transactions on Image Processing (Ranking: 16/244= 6%)**，且已申請美國專利，圖二、圖三爲目前我們所提出的演算法Adaptive Gamma Correction with Weighting Distribution (AGCWD)[3]與目前最著名的演算法結果比較圖 [40]-[45]，目前著名演算法Traditions Histogram Equalization (THE)[40]、Brightness preserving Bi-Histogram Equalization (BBHE)[41]、Dualistic Sub-Image Histogram Equalization (DSIHE)[42]、Recursive Sub-Image Histogram Equalization (RSIHE)[43]、Recursively Separated and Weighted Histogram Equalization (RSWHE)[44]、Dynamic Contrast Ratio enhancement and inverse Gamma Correction (DCRGC)[45]，皆無法獲得較好影像品質，如圖二(b) – (g) 天空與男子皮膚色彩嚴重失真或是未有任何增強效果，此外圖三道路影像，雖然目前影像增強技術對較暗區域有明顯的改善但已經損失了許多影像細節，而我們所提出的演算法Adaptive Gamma Correction with Weighting Distribution (AGCWD)[3]，可以針對不同條件下的影像有效進行影像品質提升，且不損失影像細節，證實出此演算法的學術價值、工業價值與經濟價值，具體的提升台灣面板顯示產業的競爭力。

圖一、42吋奇美智慧背光調整顯示器



圖二、"人像"影像增強比較圖：(a) 原始影像 (b) THE, (c) BBHE, (d) DSIHE, (e) RSIHE, (f) RSWHE, (g) DCRGC, (h) AGCWD.



圖三、"道路"影像增強比較圖：(a) 原始影像 (b) THE, (c) BBHE, (d) DSIHE, (e) RSIHE, (f) RSWHE, (g) DCRGC, (h) AGCWD.

然而我們所提出的演算法有大量的高運算複雜度，若是使用軟體方式，將我們的演算法實踐在高畫質的動態影片上，會無法達到高畫質的動態影片的即時處理，因此我們提出兩年的國科會研究計畫，將我們原先發展的「高畫質數位影像增強技術用於顯示器智能背光控制」軟體演算法，透過硬體的實踐，達到 「Full HD 1080p 高畫質的動態影片即時處理」。為了使設計的硬體有效的達到即時處理，並且讓我們所設計的硬體使用最少的硬體成本達到最高的處理速度，我們先將原有的演算法透過數學的方式化簡，避免大量的除法和指數運算，來達到硬體實踐的可行性，我們也將提出**<u>硬體重</u>**

<u>組架構(Hardware Reconfigurable Architecture)</u>，使用動態切換硬體再利用的方式，能大幅度減少硬體成本，透過硬體架構平行處理以及有效資源分配，達到「Full HD 1080p 高畫質的動態影片即時處理」，同時結合奇美面板原有的背光模組控制，一方面有效地針對輸入之影像明亮程度，智慧型調整背光源本身的亮度控制，將輸出影像有效的調整，改善暗處區域影像品質，以及使用影像對比度補償和細節增強之技術，其以提升整體之視覺對比度和影像細節，進而改善整體影像品質。本計畫高畫質數位顯示器增強結合背光控制技術軟體演算實踐於硬體架構，主要規劃分爲兩年：第一年，影像增強與細節強化演算法化簡爲硬體可執行架構。第二年，高效能且低成本的硬體架構實踐以及晶片下線。

第一年：影像增強與細節強化演算法化簡爲硬體可執行架構

軟體能輕易實作出除法以及指數運算，然而硬體在除法以及指數實踐上，除了較困難外相對時間也較長，所以需將演算法化簡爲適合硬體的運算，並增加運算速度，同時達到即時影像處理也能降低資料運算量。我們發表在 *IEEE Transactions on Image Processing* 的軟體演算法中含有大量除法和指數運算，不利於硬體執行與實踐，所以在實踐之前必須經過化簡，爲了有效的避免複雜的除法和指數運算，但又要保持影像的品質效果，我們將演算法的除法和指數運算，透過**<u>對數(Log)</u>**和<u>牛頓均差分內插法</u>**<u>(Newton's divided difference interpolation formula)</u>**，獲得簡化除法和指數運算的最佳近似值，我們不但化簡出硬體可實踐的演算法架構，而且化簡過後的結果與化簡前的結果誤差值極小，讓簡化的影像品質接近於原先軟體演算法的品質，此外我們也加入了<u>細節強化演算法</u>，提升整體影像的對比與細節呈現。接下來第二年將進行硬體資源分配以及資料處理排程，提升硬體運算效能。

第二年：硬體架構實踐以及晶片下線

數位視訊不斷追求高畫質，各種顯示裝置，不斷追求大尺寸，對於如此高品質與大尺寸影像，若要達成即時動態影片處理，須善加規劃硬體架構，因此爲了讓**<u>硬體導向演算法(hardware-oriented algorithm)</u>**達到最大處理效能，預計將此硬體架構切五個階層，並使用**<u>管線(Pipeline)</u>**架構進行硬體加速，然而在管線執行當中，會有某些運算單元呈現閒置，導致硬體使用率不佳，因此我們採用**<u>硬體重組架構(Hardware Reconfigurable Architecture)</u>**重新規劃硬體的使用，在不同運算方程式下進行硬體單元切換，降低硬體閒置情況，提升硬體使用率。此外我們也提出**<u>硬體摺疊架構(Hardware Folding Architecture)</u>**技術，取代傳統硬體電路，降低硬體成本，透過**<u>硬體重組架構(Hardware Reconfigurable Architecture)</u>**與**<u>硬體摺疊架構(Hardware Folding Architecture)</u>**，提升整體硬體使用率，方能及時處理「Full HD1080p 高畫質的動態影片」。

以上階段採用 FPGA 驗證此硬體演算的架構，經過驗證後的硬體架構，我們要將此硬體演算法架構晶片下線製成晶片，所以必須先經過後段晶片製程步驟，佈局、繞線與驗證，確定驗證無誤後將進行晶片下線，目標爲實踐出影像增強與細節增強晶片並且導入目前相關顯示裝置，達到高品質影像顯示。

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