



A25-002

下世代顯示與串流平台 時間空間解析度強化系統

Space and Time Resolution Enhancement System
for Next Generation Display and Streaming

隊伍名稱 | 萬佛朝宗 All Buddhas Return to One

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臺灣大學電子工程博士，現為清華大學電機工程學系教授。曾服務於聯詠科技，亦曾於麻省理工學院進行博士後研究。曾獲傑出人才基金會年輕學者創新獎、未來科技獎、中國電機工程學會優秀青年電機工程師獎、清華大學傑出教學獎、旺宏金矽獎最佳指導教授獎等獎項。

研究領域

近來研究以實現高效能、高品質之電腦視覺與計算攝影學應用為主，包含卷積神經網路處理器、立體3D光場顯示器、光場相機等相關研究，是國內極少數能同時發表頂尖論文至計算機架構 (ISCA/MICRO)、晶片設計 (ISSCC/VLSIC/ESSCIRC)、電腦視覺 (CVPR/ICCV/TPAMI) 此三大熱門研究領域之研究者。

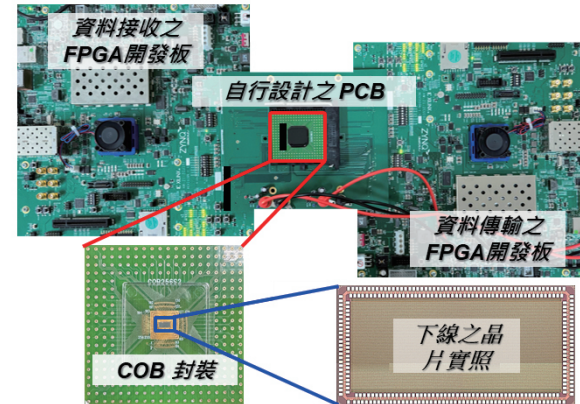
作品摘要

受益於下世代顯示技術，許多科技公司與面板廠開發許多大尺寸、高規格之顯示面板。從2021年以來，電視所能夠顯示的規格越來越高，從2021年4K-UHD (3840×2160像素) 60幀率 (Frame Per Second, FPS) 的顯示規格，到如今2024年Samsung推出8K-UHD (7680×4320像素) 120-FPS電視。然而，受限於當前影像傳輸頻寬，如Netflix串流頻寬為4K-UHD 60-FPS，這些高規格電視不能展現其高解析度的特性。

因此，本作品完成一個下世代顯示與串流平台時間空間解析度強化的系統 (如圖一)，能將低解析度QHD (960×540像素) 30-FPS之影片，即時還原至高解析度4K-UHD (3840×2160像素) 60-FPS影片。我們設計並下線一個高規格的卷積神經網路晶片，該晶片為世界第一顆能同時提升空間與時間的解析度，能產生最高8K-UHD解析度60-fps的吞吐量，實現更流暢的顯示效果；同時，整合自行設計之PCB板以及Xilinx FPGA板，開發完整的即時晶片展示系統，透過高畫質多媒體介面 (HDMI)，搭建整個解析度強化的即時展示系統，展現神經網路運算能夠有效的嵌入至當前的螢幕顯示與電視設備之中。

圖二為晶片系統展示於市售4K-UHD電視的實照，我們準備QHD低解析度影片，透過我們晶片能夠還原至4K-UHD高解析度影片，同時也提高2倍影片幀率至60-FPS，使電視螢幕可以順暢的撥放影片。為了能夠清楚的觀察我們晶片計算的結果，我們透過「放大模式」的Zoom-in View來呈現高品質計算結果，其結果在中電視顯示的右側，可以看到Zoom-in View左半部分為晶片計算結果，右半部分為傳統演算法之結果。從圖中能觀察到，由於我們採用卷積神經網路運算，使運算完的影像較為平順，與傳

統演算法相比，能夠減少更多格子狀的效果，能帶來比較好的影像品質。因此，我們期望未來能將此系統嵌入至大尺寸、高解析度之電視或螢幕中，帶給消費者更多機會體驗更沉浸的視覺體驗。



圖一 下世代顯示與串流平台時間空間解析度強化的系統。



圖二 本系統結合市售電視之實際展示照。

Abstract

Benefiting from next-generation display technologies, many tech companies and panel manufacturers have been developing large-sized, high-specification display panels. Since 2021, television display specifications have rapidly advanced—from 4K-UHD (3840×2160 pixels) at 60 frames per second (FPS) in 2021, to Samsung's 8K-UHD (7680×4320 pixels) 120-FPS TV launched in 2024. However, due to current limitations and expensive video transmission bandwidth (e.g., Netflix's streaming bandwidth supports only 4K-UHD at 60 FPS), these high-specification TVs are unable to fully demonstrate their high-resolution capabilities.

To address this issue, our work presents a real-time space and time resolution enhancement system for next-generation display and streaming platforms, as shown in Fig. 3. This system can upscale low-resolution QHD (960×540 pixels) 30-FPS videos to high-resolution 4K-UHD (3840×2160 pixels) 60-FPS in real time. We designed and taped out a high-performance convolutional neural network (CNN) chip, which is the world's first chip capable of simultaneously enhancing both spatial and temporal resolution, achieving a throughput of up to 8K-UHD at 60 FPS for smoother display performance. Additionally, we integrated a custom-designed PCB and a Xilinx FPGA board to develop a complete real-time chip demonstration system. By utilizing a High-Definition Multimedia Interface (HDMI) protocol, we built a live display platform to showcase how neural network computing can be effectively embedded into modern display and television devices.

This system can also be demonstrated on a commercial 4K-UHD television thanks to the HDMI interface as shown in Fig. 2. A QHD low-resolution video is restored to a 4K-UHD high-resolution video through our chip, with the frame rate also doubled to 60 FPS, enabling smooth playback on the TV screen. On the right side of the TV display in the image, the left half of the zoomed-in section shows the result from our chip, while the right half shows the result

of a traditional algorithm. It is evident from the image that our CNN-based processing yields smoother visual quality and significantly reduces grid-like artifacts compared to traditional methods, thereby delivering superior image quality.

In the future, we aim to embed this system into large-sized, high-resolution televisions or monitors, offering consumers a more immersive visual experience.

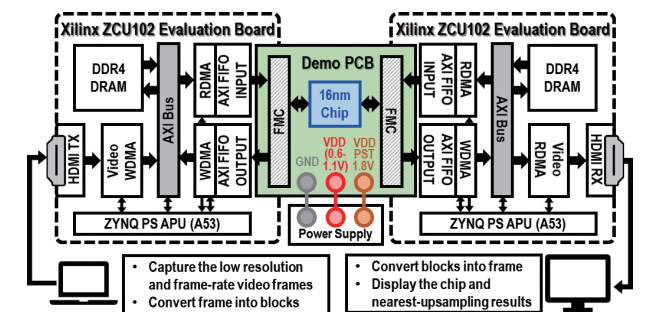


Fig. 3 Chip demonstration system architecture.