Application Group A11-120

作品名稱

可攜式擴散光學斷層掃描系統晶片設計
A Portable Design for Diffusion Optical Tomography System on Chip

隊伍名稱

SOC卓爾 SOC Drawer

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作品摘要

SOC實現了整合多顆積體電路的產品，例如MP3、行動電話等。近年來生物晶片逐漸在SOC佔有一席之地，例如生物化學偵測晶片、生物邏輯控制電路等。

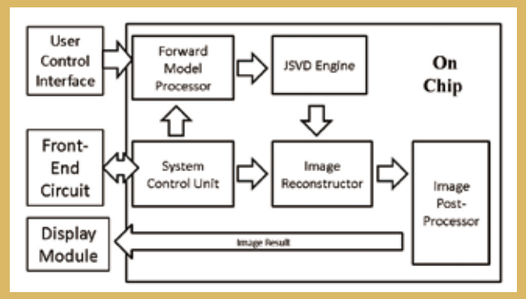
目前市面上許多儀器都非常的昂貴以及擁有龐大的體積，這項特性使這些設備只能適用於醫院中。然而我們將設計一個體積小且價而低成本的擴散光學斷層掃描系統，目的希望能使儀器微小化且能夠應用於居家照護。此系統不只便利與低成本，更提供在人體腫瘤偵測上的高準確度，並能自行判斷診斷結果，達到減少醫療人力資源的目的。

完整擴散光學斷層掃描系統包含五個重要的處理單元，包含系統控制單元、前向模型處理器、Jacobi奇異值分解處理引擎、影像重建單元以及影像後處理器，如圖一所示，描述如下:

A. 系統控制單元：系統控制單元控制範圍包含前端偵測電路的控制以及內部資料流的控制。系統提供連續模式及非連續模式供使用。
B. 前向模型處理器：根據輸入的環境參數，配合光子擴散行為模型去建構出不同深度下用來重建用的權重矩陣，內部包含控制單元、前處理單元、查表記憶體以及計算模組。
C. Jacobi奇異值分解處理引擎：此系統應用於生醫工程，因此處理引擎利用信號處理技術達到要求的高精確度、低面積以及低功號。此處理引擎主要用於反矩陣的運算，把前向處理器輸出的權重矩陣進行奇異值分解。
D. 影像重建處理器：此模組將收集到的反向解和外部信號進行內積運算藉此重建出初步的影像。
E. 影像重建後處理器：為提高影像品質，將初步的重建影像做延展與平滑。此模組包含輸入緩衝暫存器、控制單元、權重矩陣、計算單元。

為驗證此擴散光學斷層掃描系統，我們將實驗結果與Matlab模擬之結果做比較，如圖二所示。我們可以很容易的判斷系統的正確性，因為系統實驗之結果和Matlab 模擬有相同之結果。

在未來，藉由將提出的擴散光學斷層掃描系統整合於SoC 中使得低成本、可攜式及便利的居家照護系統得以實現，同時也便利醫生、病人及相關研究者。



圖一 連續擴散光學斷層掃描系統架構

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- 教授目前擔任交通大學電子工程學系台積電傑出講座教授、交通大學晶片系統研究中心主任、IEEE 系統學術會副總裁及 IEEE Fellow。
- 曾任交通大學晶片系統研究中心副主任、交通大學資訊工程學系合聘教授、交通大學電機與控制工程學系合聘教授、美國太空總署　噴射推進研究院　資深工程師/經理、美國南加州大學兼任教授、德國太空研究中心訪問科學家。
- 研究領域：包含晶片系統技術與應用研發、生醫電子工程和生物晶片研發、訊號和影像處理超大型積體電路系統、類神經網路與智慧系統、多媒體信號處理與通訊系統、應用於太空的積體微電子系統。

ABSTRACT

System-on-a-chip (SoC) design has made possible the realization of many highly-integrated consumer electronic products, for instance, MP3 players, cellular phones, and so on. In recent years, Biochip is another research field of SoC. There are many types of Biochips, for instance, biochemical measurement chips, biological control chips, and so on.

One of the safest health check-up techniques is computed tomography, and the Diffuse Optical Tomography (DOT) is the most commonly used detection method. However, existing instruments employing these technologies take up a lot of space and are very expensive, as a result finding very limited use in medical institutions and hospitals only. In order to popularize DOT for health care, it is necessary to realize DOT systems that are more convenient and less expensive. In this work, we design a low-cost DOT system suitable for portable SoC applications that can be used anytime, anywhere.

The complete DOT system comprises five processing units, including (shown Fig. 1); a system control unit, a forward model processor, a Jacobi SVD engine, an image reconstructor unit and an image post-processor. The details are described as follows.

A. System Control Unit: The system control unit is used to control both the off-chip sensor circuit and the on-chip DOT system. In this system we implement two different operation modes continues and discontinues, respectively.
B. Forward Model Processor: The forward model is used to build a theoretical model of photon transfer behavior in highly scattered tissue. The parameters of the forward model depend on the type of target as well as the observation depth.
C. Jacobi SVD Engine: The proposed JSVD processor is targeted mainly for biomedical signal processing applications, particularly portable instruments. Therefore, design requirements such as high precision, low area and low power consumption must be satisfied.
D. Image Reconstructor: The purpose of this module is to perform the inner product between the solved inverse solution and collected data to form a reconstructed image.
E. Image Post-Processor: The image post-processor is employed to expand and smooth the reconstructed image so that the result will have better observability.

To validate the proposed DOT system, the experimental results are compared against MATLAB simulations, as shown in Fig. 2. We can easily verify that the results of the proposed system matches with the results predicted by using MATLAB simulations.

Finally, by integrating the proposed DOT system into an SoC, low-cost, portable and convenient healthcare solutions can be realized, benefitting doctors, patients, and researchers alike in the future.