# A System on Chip Solution for Processing of Gamma Camera Images for Thyroid Uptake Studies

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## I. Introduction

Nuclear medical Imaging modalities such as Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) are non-invasive, in-vivo and functional. Molecular imaging technologies that have produced promising results for specific identification of cancer and other investigations which need specialized diagnosis with Gamma Camera (GC) like thyroid scan, bone hot spot study etc. This is due to their unique ability to sense and visualize increased biochemical changes in malignancy zone as compared to healthy tissue well before structural changes can occur.

These studies involve handling massive data coming out due to the gamma interactions inside the detector and a lot of processor power is used up to handle it. This slows down the imaging process which leads to longer imaging times. **In this study, a system on chip design is attempted to reduce the CPU power required for Thyroid image processing.**

In Thyroid Uptake Studies (TUS), a radio pharmaceutical (also known as tracer) such as Technetium-99m, Iodine-123, Iodine-131 is injected into patient's body. TUS indicates the measure of concentration of tracer (counts) which the thyroid gland absorbs from the blood stream.

This study is also useful for diagnosis of Hypothyroidism (resulting in less uptake), Hyperthyroidism (resulting in more uptake). As per the medical standards for TUS, a person with uptake >2% is considered to be Hyperthyroidism, uptake < 0.5% is Hypothyroidism. [1]

Gamma rays are emitted from the patient's body. These radiations are detected by dual head detector of GC that contains Low Energy All Purpose (LEAP) collimator of parallel hole type, scintillating crystal, Photo-Multiplier Tube (PMT), preamplifier, pulse shaping electronics and finally image processing tools for formation of image.

The thyroid uptake value is calculated from the counts of:

a. Full Syringe with Tc99m for a minute
b. Anticubital (tracer injected portion) for a minute
c. Thyroid portion for 10 minutes
d. Empty Syringe (Tracer left in Syringe) for a minute

It is calculated using the following formula:

$$\text{Uptake percentage (\%)} = \frac{\text{Thyroid cpm-Background cpm}}{\text{Standard cpm}} * 100$$

$$\text{cpm} = \text{counts per minute}$$

$$\text{Standard cpm} = (\text{Full syringe counts} - \text{Empty syringe counts} - \text{Anticubital counts})$$

## II. Hardware Design

Our prototype is a part of a fully digital data acquisition [2]. It is designed using a BF609 DSP processor with dual cores from Analog Devices. The prototype is used for processing tasks like finding thyroid uptake value from thyroid studies.

### A. Signal Chain developed in prototype

To realize the task of finding the counts in the selected ROI, pipelined vision processor (PVP) is used. A PVP is a hardware accelerator for image and video processing operations. The advantage of PVP is that its operation is independent of the dual core engine. A signal chain for achieving our task is developed for proposed prototype is as shown in Fig.1.


**Fig.1. Signal Chain developed to calculate the counts**

Direct Memory Access (DMA) is allocated to PVP memory pipe data input. Input Formatter (IPF) extracts data from the memory pipe. The images for thyroid uptake are processed using developed prototype. To find the counts in the selected region we have used Integral image computation (IIM) block of PVP. Output formatters (OPF) of PVP serves the memory pipe. Output from the PVP will exit through the DMA channel [3].

### B. Algorithm Implementation

The developed prototype is used for counting the number of pixels in the selected region of interest (ROI). For selecting the thyroid portion of a given image (Fig.2.), ROI selection method algorithm is implemented. ROI selected for the tracer accumulation in the thyroid, salivary glands, mediastinum and other parts of body shown in Fig.3. (a). The Fig.3. (b), shows the processed image that segments only the thyroid region which is the ROI.

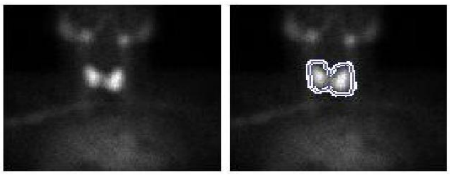

**Fig.2. Thyroid Scan from Gamma Camera and its ROI selection**

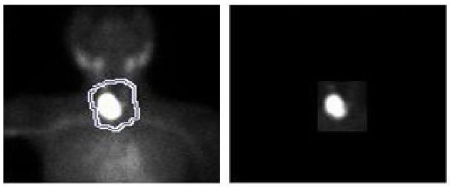

**Fig.3. (a) ROI selection Fig.3. (b) Processed Image**

## III. Simulation Results and Analysis

We have considered the data from the department of nuclear medicine, Sri Sathya Sai Institute of Higher Medical Sciences (SSSIHMS), a super specialty hospital, to compare the performance of our developed prototype. A total of 27 thyroid cases had been obtained from SSSIHMS for processing in our prototype. The results thus obtained are used for calculating the thyroid uptake percentage. (Fig.4.).

A comparative analysis is done between the results obtained from the algorithm implemented in system on chip hardware accelerator and the results of post processing tool of Siemens E-CAM used at SSSIHMS for this study.

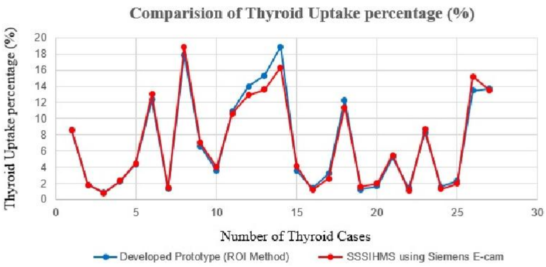


**Fig.4. Graph comparing uptake % obtained from prototype and Siemens E-CAM (SSSIHMS)**

The counts in the ROI are given by the developed signal chain (Fig.1.). The comparative results of counts for 27 patients obtained using ROI method in prototype and using post processing tool of commercially available Siemens E-CAM are plotted in (Fig.5.).

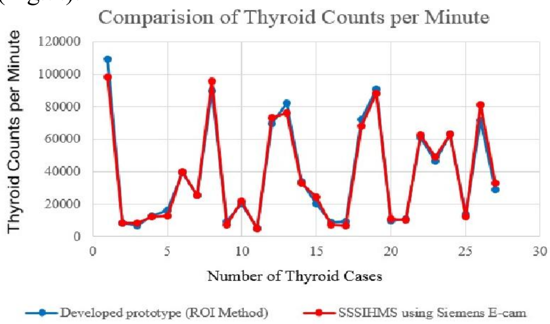


**Fig.5. Graph comparing Thyroid counts obtained from Prototype and Siemens E-CAM**

The error percentage is calculated using:

$$\text{Error } \% = \frac{|(estimated - observed)|}{estimated} * 100 \quad (2)$$

Where 'estimated' is the result obtained from SSSIHMS and the 'obtained' is the result from prototype. Using (2) the error percentages for all the patients in terms of thyroid uptake percentages are calculated. Error % for this parameter lies in between 0.5% and 10% for most of the cases.

## IV. Conclusion

The performance of the designed system is evaluated by running the developed algorithm for known thyroid images. **Results obtained using ROI algorithm implemented in prototype is in closer resemblance with the results from commercially available Siemens E-CAM being used in the hospital.** This System on Chip design facilitates freeing up of the Host computer's processing power to a large extent thus speeding up of the imaging process. Study is currently on at SSSIHL to quantify the processing load reduction achieved by incorporating this design.

## References:

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