

## Automated Analysis of Standard Uptake Value for Torso FDG-PET Images

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**ABSTRACT:** The purpose of this work was to develop an automated method to calculate the z-score of SUV for torso region on FDG-PET scans. The three dimensional distributions for the mean and the standard deviation values of SUV were stored in each volume to score the SUV in corresponding pixel position within unknown scans. The modeling methods is based on SPM approach using correction technique of Euler characteristic and Resel (Resolution element). We employed 193 normal cases to assemble the normal metabolism distribution of FDG. The physique were registered each other in a rectangular parallelepiped shape using affine transformation and Thin-Plate-Spline technique. The regions of the three organs were determined based on semi-automated procedure. Seventy-three abnormal spots were used to estimate the effectiveness of the scoring methods. As a result, the z-score images correctly represented that the z-scores for normal cases were between zeros to plus/minus 2 SD. Most of the z-scores of abnormal spots associated with cancer were larger than the upper of the SUV interval of normal organs.

**KEYWORDS:** FDG-PET, SUV, automated detection

### I. INTRODUCTION

2-deoxy-2-fluoro-d-glucose (FDG) - Positron Emission Tomography (PET) scans has been used to detect metastasis in cancer diagnosis in whole body. The FDG-PET image indicates the metabolism of radioactive glucose. Standard Uptake Value (SUV) is the important measurement to represent the degree of the metabolism, but the value often depended on the patient condition, the dose of FDG, and the measurement terms and methods for the radioactivity of FDG when the medicine was injected [1, 2].

The purpose of this work was to develop a quantitative measurement method to show a normality of the metabolism of FDG and to confirm the fundamental technique for CAD approach of whole body scanning using FDG-PET.

A typical quantitative measurement approach is a scoring method, in which the interval of values from normal groups were determined by the mean ( $m$ ) and the standard deviation ( $SD$ ) and the z-score for value  $p$  is defined as  $(p-m)/SD$ . The scoring approaches in PET scans were well employed in functional MRI and PET for brain imaging [3].

In this work, we have developed an automated method to calculate the z-score of SUV (standard uptake value) for torso region on FDG-PET scans. As an initial work, we

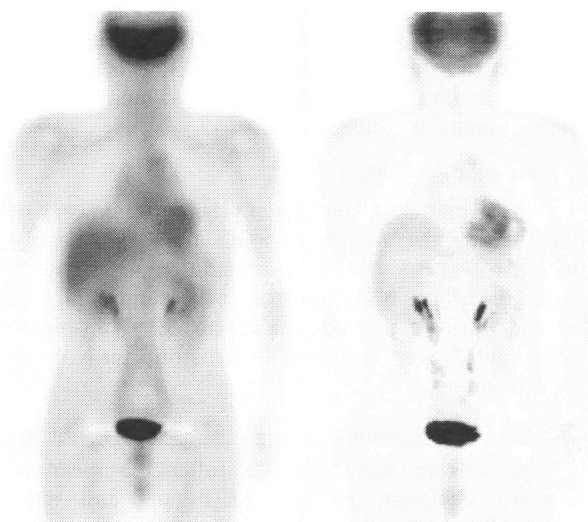
employed small number of normal cases in cancer screening program to assemble the metabolism distribution for SUV of FDG inside of normal body such as brain analysis using fMRI and PET/SPECT.

### II. MATERIALS AND METHODS

Registration schemes of body surface, physique and organs are required to calculate the mean and standard deviation.

#### A. Bladder extraction

Bladder and urinary tract have gathering spot of FDG because the passage has the excretion path from kidney. The SUV value of bladder has large changes while patients passes urine before the FDG drug was injected, the density of the drug depends on the condition of health. All of the patients have large SUV region in bladder. The large volume with over 5.0 SUV area upper inguinal region was determined as a bladder.



Left: Average. Right: Standard Deviation  
Fig.1 SUV model from normal cases.

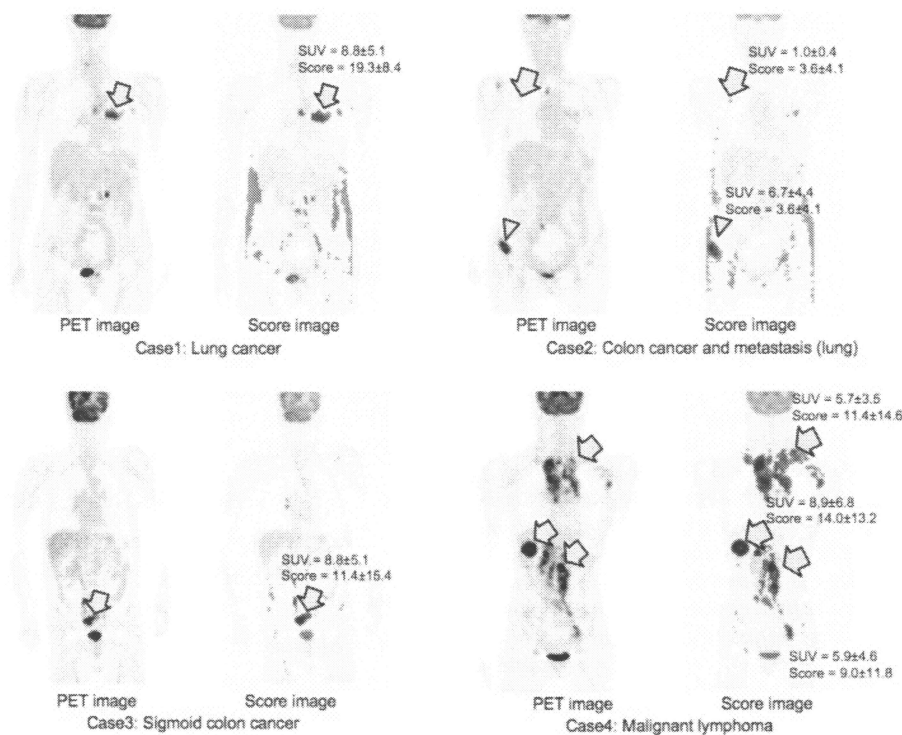


Fig.2 Four Malignant cases of FDG-PET images with score

### B. Liver extraction

The liver extraction scheme has a manual approach to select the upper(head) and below(foot) surface of liver in axial image. The normal SUV interval we investigated was 1.81(m) and 0.53 (SD). Whole liver region was estimated based on the surface and the interval not to include kidney region manually. Finally, the upper and below slice of liver on axial image was determined.

### C. Image registration

The bladder and liver region was registered each other by transforming the volume of FDG image to one coordinate body region. Body surface registration is also applied to match the whole body registration by setting 24 landmarks on the surface per one axial image. Thin-plate spline technique [5] was employed to transform the volume using those landmarks.

### D. Z-Score definition

The z-score was calculated after the mean and the standard deviation for normal organs and area were determined. Manually extracted regions from those normal scans were used to estimate the interval for the SUVs for normal organs and regions. The normal scans were registered using thin-plate-spline technique after the setting of the landmarks on the body surface. The three dimensional distributions for the mean and the standard deviation values

were stored in each volume to z-score the SUV in corresponding pixel position within unknown scans.

If the  $m$  and the  $SD$  at pixel position  $(x, y, z)$  from all registered cases were given as  $m(x, y, z)$  and  $SD(x, y, z)$ , the z-score  $Z(x, y, z)$  of  $P(x, y, z)$  in unknown cases was defined as:

$$Z(x, y, z) = \{P(x, y, z) - m(x, y, z)\} / SD(x, y, z)$$

The  $Z(x, y, z)$  shows the z-score volume for the unknown cases and represents the abnormality of SUV by estimating the normal interval as a distance from the mean and the variance of the SUV depending on organs and functions.

Figure 1 shows the coronal slice of male 3D model of the mean and standard deviations from 100+ male cases. The z-score is calculated from the two volume data after the patient scans were registered to the normal model.

## III. RESULTS

We employed 193 normal cases to assemble the normal metabolism distribution of FDG and 71 abnormal spots of cancer in lung, liver, colon, and metastasis spots in abdominal area. As a result of this work, the t-test of SUV showed the statistical significant difference between normal area and abnormal spots in corresponding regions. The z-score images correctly represented that the z-scores for normal cases were between zeros to plus/minus 2 SD. Most of the z-scores of abnormal spots associated with cancer and

cancer metastasis were larger than the upper of the interval of 2 SD calculated from normal organs. Figure 2 shows four abnormal cases on FDG-PET scans. The malignant spots on each scan were of cancer with over SUV 3.0, the z-scores of the spots were corrected to the regulated deviation. Seventy-three abnormal spots were used to estimate the effectiveness of the scoring methods. As a result, the z-score images correctly represented that the z-scores for normal cases were between zeros to plus/minus 2 SD. Most of the z-scores of abnormal spots associated with cancer were larger than the upper of the SUV interval of normal organs.

#### IV. CONCLUSIONS

We proposed an scoring method for FDG-PET scans. It may be useful as a diagnostic indication for whole body cancer screening. We employed 193 normal cases to create the model and 73 abnormal spots to estimate the z-score effectiveness. The image registration technique has manual procedures to determine the liver region, the registration scheme will be useful to enhance the interval changes of FDG-PET SUV when the patient underwent an chemotherapy.

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#### REFERENCES

- [1] John W, "SUV : Standardized Uptake or Silly Uptake Value", *J Nucl Med*, vol.36, no.10, pp.1836-1839.1995. J. Clerk Maxwell, *A Treatise on Electricity and Magnetism*, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.
- [2] Wang Y, "Standardized Uptake Value Atlas : Characterization of Physiological 2-Deoxy-2 - [18F] fluoro-D- Glucose Uptake in Normal tissues," *Mol. Imaging Biol*, vol.9, pp.83-90, 2007.
- [3] Worsley KJ, "Three-Dimensional Statistical Analysis for CBF Activation Studies in Human Brain," *J Cereb Blood Flow Metab*, vol.12, pp.900-918, 1992.
- [4] Ashburner J, and Friston KJ, "Voxel-based morphometry--the methods", *NeuroImage*, 11, 805-821, 2000.
- [5] Bookstein FL, " Principal Warps: Thin-Plate Splines and Decomposition of Deformation," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol.11, no.6, pp.567-585, 1989.