OPTIMIZING THE QUALITY OF POSITRON EMISSION TOMOGRAPHY (PET) IMAGE USING FILTERING METHODS

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DEDICATION

I dedicate this Final Year Project thesis to my parents, families, supervisor, and friends, who always understand and support me to finish this project and make this project possible. Thank you.

ABSTRACT

Positron Emission Tomography (PET) is a medical imaging machine that assists in discovering the metabolic or biochemical activity of tissues and organs. A radioactive substance (tracer) is used in the PET scan to show normal and abnormal metabolic activity. However, the image produced by the PET machine seems to be low quality, making it challenging for doctors and physicians to diagnose a disease. This project aims to enhance the quality of the PET image by using the filtering image methods. Therefore, the MATLAB software for reconstructing the PET image is used in this project. The filtering method is used to enhance the quality of the PET images. The filtering methods used in this project are None filter, Hann filter, Hamming filter, Cosine filter, Ramp filter, and Sheep-logan filter. Based on the qualitative approach, there are 79 respondents that responds to the survey, and the majority of the respondent agree that the Hann filter is the best filter to enhance the PET image. While from a quantitative approach, based on the image quality metric, the Signal-to-Noise Ratio (SNR) shows that the Hann filter give the highest SNR value. Overall, the result from this research shows an improvement in the quality of the PET image by implementing filtering methods to remove the noise from the PET image.

ABSTRAK

'Positron Emission Tomography' (PET) adalah salah satu mesin pengimejan dalam bidang perubatan yang membantu menemukan aktiviti metabolik dan biokimia dalam organ manusia. Bahan radioaktif digunakan dalam pengunaan mesin PET untuk menunjukkan aktiviti normal dan tidak normal dalam organ manusia. Namun begitu, imej yang dihasilkan daripada mesin PET ini mempunyai kualiti yang rendah, menyebabkan para doktor mengalami kesukaran untuk mendiagnos sesuatu penyakit. Tujuan projek ini untuk menambahbaik kualiti imej PET dengan menggunakan kaedah imej penapisan. Oleh itu, perisian MATLAB digunakan di dalam projek ini. Kaedah penapisan imej yang digunakan dalam projek ini ialah 'None filter', 'Hann filter', 'Hamming filter', 'Cosine filter', 'Ramp filter', dan 'Shepp-Logan filter'. Berdasarkan daripada pendekatan kualitatif, seramai 79 orang responden yang menjawab tinjauan ini bersetuju bahawa 'Hann filter' adalah imej penapisan yang terbaik untuk meningkatkan kualiti imej PET. Manakala pendekatan kuantitatif menunjuk, nilai kualiti imej metrik, 'Signal-to-Noise Ratio' (SNR) yang tertinggi terhasil daripada penapisan imej 'Hann filter. Secara keseluruhan, hasil daripada kajian ini menunjukkan peningkatan kualiti imej PET dengan cara penapisan imej untuk menghilangkan bunyi daripada imej PET.

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LIST OF SYMBOLS AND ABBREVIATIONS

PET	:	Positron Emission Tomography
SNR	:	Signal-to-Noise Ratio
RC	:	Recovery Coefficient
CNR	:	Contrast-to-Noise Ratio
WHO	:	World Health Organization
MRI	:	Magnetic Resonance Imaging
CT	:	Computerized Tomography
SPECT	:	Single Photon Computed Tomography
FYP	:	Final Year Project
MLEM	:	Maximum-Likelihood Expectation-Maximization
EM	:	Expectation-Maximization
TOF	:	Time-Of-Flight
PSF	:	Point Spread Function
FBP	:	Filtered Back Projection
SPM	:	Sijil Pelajaran Malaysia
FWHM	:	Full Width Half Maximum
SD	:	Standard Deviation
VOI	:	Value of Interest
SEM	:	Scanning Electron Microscope

PNG	:	Portable Network Graphics
FFT	:	Fast Fourier Transform

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The Positron Emission Tomography (PET) machine is a medical imaging machine that assists in discovering the metabolic or biochemical activities of tissues and organs. A radioactive substance or tracer is used in the PET scan to show the human body's normal and abnormal metabolic activities. In this project, a number of filtering method is tested to enhance the PET image. Hence, this chapter will clarify the project background, problem statement for this project, the project objectives, scope of the project, and the significance of this project to society.

1.2 Project Background

PET is an efficient and advanced technique widely used in clinical applications, including tumor detection and neurologic disorders [1]. The PET machine will eventually produce an image that doctors use to diagnose the patients. PET imaging is the distribution of radioisotope-identified chemical compounds injected into the human body that can display biological and physiological processes, which can help doctors discover diseases early. It has become one of the essential components of modern nuclear medical diagnostics [2]. Hence, nuclear medicines are important nowadays, especially in medical imaging.

PET imaging is used to diagnose, assess, and treat various disorders such as cancer, heart disease, gastrointestinal, endocrine, or neurological diseases. PET imaging scans, on the other hand, highlight molecular activity. They will be able to detect disease in its early stages due to this advance technology. They can also demonstrate how well the treatment is done on the patient. However, PET imaging produces a low-quality image that needs to be enhanced to improve the quality PET image to help doctors diagnose disease.

The quality of the PET image is crucial to help doctors diagnose the patient. Unfortunately, current PET technology does not give the image quality required for such exact analytic and quantitative data. Due to the inexactness of the models employed in image reconstruction, PET images have very high levels of radial noise in the form of streaks [3]. On the other hand, conventional PET image iterative reconstruction algorithms cannot filter noise adequately [4]. Hence, this project will focus on the filtering method to enhance the PET image.

Post-reconstruction filtering is now one of the most widely used noise reduction strategies in clinical practice. However, the range of available filters is enormous. Selecting the best filter for a given measurement is not easy [5]. Thus, many filtering methods include the Hann filter, Gaussian filter, Hamming filter, Cosine filter, and Ramp filter are used. Eventually, by using the filtering method, the quality of the PET image will be improved. The post-filtering PET image can be analyzed and determined using the image quality matric.

The image quality metric is a parameter used to know the improvement of the quality of the PET image. The Recovery Coefficient (RC) and the Contrast-to-Noise Ratio (CNR) are two metrics used to assess the quality of images produced by different filtering methods [5]. The number of coincident events collected during PET imaging is restricted, and mistakes occur due to attenuation, normalization, scattering, and random effects. As a result, a PET measurement's signal-to-noise ratio (SNR) is usually low [6]. Hence, the higher the value of SNR, the better the quality of the PET image.