FINAL PROJECT

HELIX TRACK IDENTIFICATION IN ALICE TIME PROJECTION CHAMBER DATA USING THE HOUGH TRANSFORM AND KALMAN FILTER

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TUGAS AKHIR

IDENTIFIKASI LINTASAN HELIX PADA DATA DETEKTOR TIME PROJECTION CHAMBER (TPC) DI ALICE MENGGUNAKAN TRANSFORMASI HOUGH DAN FILTER KALMAN

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LEMBAR PENGESAHAN

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Bandung, 13 Juli 2018

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PERNYATAAN

Dengan ini saya yang bertandatangan di bawah ini menyatakan bahwa tugas akhir dengan judul:

HELIX TRACK IDENTIFICATION IN ALICE TIME PROJECTION CHAMBER DATA USING THE HOUGH TRANSFORM AND KALMAN FILTER

adalah benar-benar karya saya sendiri, dan saya tidak melakukan penjiplakan atau pengutipan dengan cara-cara yang tidak sesuai dengan etika keilmuan yang berlaku dalam masyarakat keilmuan.

Atas pernyataan ini, saya siap menanggung segala risiko dan sanksi yang dijatuhkan kepada saya, apabila di kemudian hari ditemukan adanya pelanggaran terhadap etika keilmuan dalam karya saya, atau jika ada tuntutan formal atau non-formal dari pihak lain berkaitan dengan keaslian karya saya ini.

Dinyatakan di Bandung,

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Abstract

Helix track detection and filtering using the ALICE Time Projection Chamber (TPC) data was done. The detection and filtering was done with data from a Monte Carlo simulation and another simulation based on the derived helix equation, using the Hough Transform and the Helix Kalman Filter. Not all tracks recorded by TPC are useful, this project aims to classify the unnecessary helix tracks data points and store it in parameters to reduce the need for extra storage. The classifier used in this project is the Chi2 error calculation. The results show that the proposed method can be implemented to classify helix tracks. Derivation of the helix track equation and a brief introduction to CERN's LHC, ALICE TPC and physical phenomenon in the detector are provided.

Keywords: ALICE, Time Projection Chamber, Helix Tracks, Hough Transform, Kalman Filter.

Abstrak

Proses deteksi dan filter lintasan Heliks dari data Time Projection Chamber (TPC) pada ALICE telah dilakukan pada tulisan ini. Proses deteksi dan filter dilakukan menggunakan Transformasi Hough dan Filter Kalman dengan data yang dihasilkan dari simulasi Monte Carlo dan simulasi lain dengan prinsip yang dihasilkan dari penurunan persamaan gerak heliks. Tidak seluruh lintasan yang direkam TPC berguna untuk analisis, tulisan ini bertujuan untuk mengklasifikasi titik-titik dari lintasan heliks untuk kemudian disimpan dalam sebuah parameter untuk mengurangi kebutuhan kapasitas penyimpanan data. Dasar klasifikasi pada tulisan ini adalah perhitungan kesalahan dengan Chi2. Hasil menunjukan bahwa metode yang direncanakan dapat diimplementasikan untuk mengklasifikasi lintasan heliks. Penurunan persamaan gerak heliks dan pengantar untuk LHC di CERN dan TPC di ALICE telah diuraikan di dalam tulisan ini.

Kata-kata Kunci: ALICE, Time Projection Chamber, Lintasan Heliks, Transformasi Hough, Filter Kalman.

PREFACE

First of all I would like to praise and thank the presence of Allah Subhanahu wa ta'ala, for the abundance of grace and blessings so the final project titled "Helix Track Identification in ALICE Time Projection Chamber Data using The Hough Transform and Kalman Filter" can be finished. The writing of this final project is done as a requirement to earn the degree of Bachelor of Science (Sarjana Sains) from the Faculty of Information Technology and Science of Parahyangan Catholic University. I would like to thank everyone for helping, supporting and giving me advice throughout the process of writing this paper, my utmost gratitude for every entities.

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Bandung, July 2018

Writer

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1 Introduction

1.1 Motivation

Since the beginning of time, human beings have always tried to understand the world around them with philosophy and by proving it with measurement. The advancement of technology and science has encouraged humans to continue conducting experiments. Human beings are able to observe more and more, not just in the macroscopic realm, but also in the microscopic world. One remarkable fact, particularly relevant to the present research, is that matter at the subatomic level consists of tiny chunks, with vast empty spaces in between.

The dawn of quantum physics brings new mystery and hope for the future, because the observation of these tiny chunks is finally possible. The first real breakthrough came in 1900 when Max Planck introduced the concept of quantum energy. In his efforts to explain the phenomenon of blackbody radiation, he succeeded in reproducing the experimental results only after postulating that the energy exchange between radiation and its surroundings takes place in discrete, or quantized, amounts. Planck's idea, which gave an accurate explanation of blackbody radiation, prompted new thinking and triggered an avalanche of new discoveries that yielded solutions to the most outstanding problems of the time. In summary, quantum mechanics is the theory that describes the dynamics of matter at the microscopic scale [1]. Even more remarkable, these tiny chunks come in a small number of different types (electrons, protons, neutrons, pi mesons, neutrinos, and so on), this has led to the development of Particle Physics. The early observation of the exotic tiny chunks (particles) used cosmic rays, but they had two major disadvantages, the rate at which they strike the detector of any reasonable size is very low, and they are completely uncontrollable. Consequently, cosmic ray experiments called for great patience and luck [2].

In order to reproduce the creation of exotic particles, scientist discovered that it is possible to start with electrons or protons, accelerate them to high energy levels, and smash them into a target. Through skillful arrangement of absorbers and magnets, scientists can separate the particle species that they wanted to study from the resulting debris. In general, the heavier the particle needed to be produced, the higher must be the energy of the collision. Using mechanical theorem it turns out that if two high-speed particles collided head-on, the energy gain is enormous compared to firing one particle at a stationary target.

In 2008 the Large Hadron Collider (LHC) at CERN started generating data. The LHC is designed to reach high beam energy. At first it started with 7 to 8 TeV of total beam energy, and was restarted in early 2015 for its second research run, reaching 6.5 TeV per beam (13 TeV total, the current world record). LHC is the biggest experiment complex in the world. One of them is A Large Ion Collider Experiment (ALICE) which is on a quest to find the secret of the early beginnings of the universe which is the soup of quark gluon plasma.

The next upgrade of the LHC will be conducted during the second long shutdown (LS2: 2019-2020)[3]. In the process of the upgrade, many institutions are trying to provide a better algorithm to analyze the results in order to draw conclusions, LIPI (Indonesian Institute of Sciences) has also joined the experiment enabling Indonesia's involvement in the subatomic particle adventure.

1.2 Objectives and Benefits

This project aims to help the data processing mechanism in ALICE, by optimizing the algorithm made by Rifki Sadikin which is a Loops Finder using the Hough Transform and Kalman Filter. Optimizing the parameter by further implementation of the algorithm to various data sets will hopefully increase the probability of identifying the Helix Trajectory closer to the actual measurement. It is hoped that this project will help ALICE decrease the need for extra storage, because by eliminating the unnecessary Helix Track and only storing its parameters, the size of the stored files will be greatly reduced, thus enabling scientists to use the extra storage to conduct various observations and analysis.

1.3 Overview

The final project will be presented starting from Chapter 2 which includes an introduction to the experiment and theories relevant to this final project. A brief explanation of the CERN Large Hadron Collider (LHC) is given in Section 2.1 which includes the explanation of A Large Ion Collider Experiment (ALICE) and the overview of ALICE Time Projection Chamber (TPC) detector. A brief explanation of the Helix Trajectory equation be covered in Section 2.2, Section 2.3 explaining the physical phenomenon happened in particle detectors. Section 2.4 will explain the Hough Transform and Section 2.5 will briefly explain Kalman Filter that will be used in the algorithm to identify the Helix Trajectory. Followed by an explanation of the Source of the Data in Section 2.6. In Chapter

3 the methodology of Identifying the helix track from Monte Carlo, Derived Helix Simulation and Helix Kalman Filter will be explained in Section 3.1, Section 3.2 and Section 3.3. In Chapter 4 the results of the algorithm will be discussed and further analyzed. The final section consists of Conclusion and Outlook.