Object Tracking in Surveillance System using Gaussian-Sum Filter And ACF Detection

Christanto Febrian Wibisono
School of Computing
Telkom University
Bandung, Indonesia
febrianwibisono@student.telkomuniversity.ac.id

Hilal Huda
School of Computing
CAATIS, Tel-U
Bandung, Indonesia
hilalh@teluapp.org

Muhamad Irsan
School of Computing
Telkom University
Bandung, Indonesia
irsanfaiz@telkomuniversity.ac.id

Aji Gautama Putrada
School of Computing
Telkom University Jakarta
Jakarta, Indonesia
ajigps@telkomuniversity.ac.id

Syifak Binti Izhar Hisham
Science Computer
Universiti Malaysia Pahang Al-Sultan Abdullah
Pekan, Malaysia
syifakizhar@umpsa.edu.my

***Abstract*— This paper presents a study on object tracking in surveillance systems using Gaussian-Sum Filter and Aggregate Channel Features (ACF) detection to address the challenges of accurately tracking multiple objects in dynamic environments. Object tracking is crucial in computer vision, with applications from surveillance and security to autonomous navigation and robotics. This study employs the Gaussian-Sum Filter, a proven Bayesian filtering algorithm known for its predominance in non-linear scenarios, which keeps object tracking more consistent over time. However, since the ACF detection method can detect objects over multiple frames with higher accuracy than our initial detections, we combine it with initial ones. Performance testing is conducted across four datasets, using key metrics such as precision, Multiple Object Tracking Precision (MOTP), and Multiple Object Tracking Accuracy (MOTA) to evaluate effectiveness. The results show that while Gaussian-Sum Filter combined with ACF detection achieves different precision with specific datasets (7%-98%) and MOTP rates (10%-73%), challenges arise in maintaining uninterrupted tracking accuracy, as evidenced by very low MOTA (-6%-10%) and a significant rate of false negatives, especially in complex scenarios with occlusions. These findings suggest that although Gaussian-Sum Filter and ACF detection are effective for initial detection and data handling, enhancements or hybrid methods may be required for applications demanding high accuracy in continuous multi-object tracking.**

Keywords— Object Tracking, Multi-Object Tracking (MOT), Gaussian-Sum Filter (GSF), Aggregate Channel Features (ACF), Computer Vision

I. INTRODUCTION

A. Background

Object tracking is an important task in computer vision that focuses on detecting and following objects in a series of images. Object tracking applicable in areas such as traffic monitoring, video surveillance, and digital city infrastructure [1]. Object tracking is usually divided into two main types based on the task. Single Object Tracking (SOT) is used to follow one specific target in a video, while Multiple Object Tracking (MOT) or Multiple Target Tracking (MTT) is used to track several objects at the same time [2].

Several studies have revealed that object tracking is essential in computer vision. One study showed that tracking moving objects in video image sequences is important in computer vision. This study also focused on object tracking, which has already been used in many areas of computer vision, including video surveillance, artificial intelligence, military guidance, safety detection, robot navigation, and medical and biological applications. [3]. Han *et al.* [4] also explain that Object tracking is the process of detecting and following objects as they move through video frames which involve identifying objects predicting their movement and continuously updating their position over time while addressing challenges like occlusion changes in appearance and complex movements to ensure accurate and continuous tracking of objects in dynamic environments such as surveillance or sports. Furthermore, other studies have investigated among the various nonlinear estimators, the Gaussian Sum Filter (GSF) stands out as a flexible and effective method for addressing nonlinear estimation problems, it provides a robust framework that can adapt to different types of estimation tasks, making it a valuable tool in many fields, over time, the GSF has been extensively studied and discussed in numerous research papers, highlighting its importance and versatility in solving complex estimation challenges [5]. In the context of Multiple Object Tracking Luo *et al.* [6] explain Multiple Object Tracking (MOT) or something that is more frequently referred to as Multiple Target Tracking (MTT), enables computer vision systems to detect the location of multiple objects in a scene while also re-identifying each object across frames to produce their trajectories over the sequence, this process plays a critical component in any kind of surveillance and tracking tasks. In data association-based MOT, the tracking performance is heavily affected by the detection results [7].

Gaussian filter is a Bayesian technique for state estimation in systems characterized by Gaussian-distributed states and noise. By updating the state estimate using Bayesian principles and new observations, it provides an efficient approach for systems with linear dynamics, as seen in the Kalman Filter and its variants. Dore *et al.* [8] Bayesian approach in video tracking offers a robust framework for managing uncertainties and improving object tracking accuracy by integrating motion dynamics and noisy observations, with recursive updates that enable adaptation to