Review on Odometry Techniques in Robotics Applications

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***Abstract*: With speedy advancements within the location of robotics and automation, a developing want has arisen in the direction of accurate navigation and localization of transferring gadgets. Modern sensors and algorithms are required for shifting robots with the capability to understand their environment, and enable the deployment of novel localization schemes, which include odometry, or Simultaneous Localization and Mapping (SLAM). For self sufficient navigation, movement tracking, and obstacle detection and avoidance, a robotic need to preserve information of its function over the years. Imaginative and prescient-based totally odometry is a sturdy approach applied for this cause. It lets in a automobile to localize itself robustly with the aid of the usage of best a movement of pix captured through a camera connected to the vehicle. This paper presents a top level view of present day odometry techniques, packages, and demanding situations in cell robots. The observe offers a comparative evaluation of different techniques and algorithms related to odometry and emphasizing on its efficiency and different characteristic extraction functionality, and programs. In this paper we have done a rigorous literature survey on odometry techniques and presented it in a proper format.**

Keywords: Odometry, Autonomous Navigation, Motion Tracking, Visual Odometry, Feature-Based Approach, Localization Sensors.

I. INTRODUCTION

As the automation in different engineering fields is rising rapidly, mobile robotics is gaining huge popularity. The unmanned vehicle is one such example. In the case of vehicles, visual odometry helps in estimation of movement data with the aid of cameras and sensors that are mounted over the vehicle[1]. A wide variety of sensors have been used in odometry and SLAM algorithms. Some have used LiDAR, or IMU and GPS based approaches [14]. The visual odometry system consists of a particular camera arrangement, hardware platform and the software architecture to output camera pose at a time instant. Vo techniques are sensitive to environmental changes such as lightning, texture of the surroundings, physical entities etc. [1]. Majority of the placing systems in the market count on the utilization of Global Navigation Satellite Systems (GNSS), and, the Global Positioning System (GPS). However, the GPS cannot be completely relied upon in certain conditions, so in order to enable the usage of self-controlled vehicles in unfavorable cases, alternative solutions shall be yielded to compensate the unavailability of GPS/GNSS [12]. Vision odometry techniques include image acquisition and processing, such as, calibration and distortion of lens, feature-matching, triangulation, trajectory drift due to dead-reckoning which leads to outliers that get interrupted by man-made errors, to avoid which VO schemes have to be made robust[1]. Various types of cameras, such as stereo, monocular, stereo or monocular omnidirectional, and RGB-D (color and depth) cameras, can be employed for VO goals [2].

This paper includes the methodologies of outrunning the traditional approaches of navigation with the ideology of visual odometry. The geometric VO techniques are the ones that analyze camera geometry for motion estimation whereas, the learning-based VO method aims regression model for motion estimation parameter when fed with labelled data [1]. The purpose of prioritizing VO over other localization systems like laser and sonar is that it does not emit any detectable energy into the environment, and also does not require the existence of other signals [2]. The rest of the paper is sub-divided into various sections. It provides details about the advancement of visual odometry under distinct sub-categories, that is, aspect-based, appearance based and learning-based along with some discussion on RGB-D based VO scheme. A section supplies a list of various datasets specific to visual odometry and their bounded areas.

II. LITERATURE SURVEY

Shashi Poddar, Rahul Kottath, Vinod Karar [1]

This paper introduces the topic of vision-based motion estimation, also known as visual odometry, and discusses the evolution of techniques over time. Two broad categories of approaches are covered: geometric and non-geometric. Geometric methods use geometric models and techniques, while non-geometric methods use machine learning to estimate camera motion. Three distinct classes of visual odometry schemes are described: feature-based, appearance-based, and hybrid schemes that combine features from both approaches. The paper also provides a list of datasets used for benchmarking and evaluation.

Mohammad O A Aqel, Mohammad H Marhaban, M Iqbal Saripan ,Napsiah Bt Ismail[2]: The authors of this paper provide a review of modern visual odometry (VO), including its types, methods, uses, and challenges. They compare the most widely used localization methods and sensors such as global positioning systems, inertial navigation systems, and laser sensors, with VO. The article also highlights

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future research directions in various areas. One reliable method discussed in the article is vision-based odometry, which enables a vehicle to robustly localize itself by relying solely on a stream of images captured by a camera mounted on the vehicle.

Ke Wang,Sai Ma, Junlan Chen, Fan Ren, Jianbo Lu[3]: The objective of this paper is to investigate how deep learning can enhance and optimize visual odometry (VO) systems. The authors establish criteria such as accuracy, performance, scalability, dynamicity, practicability, and extensibility, and use them as a basis for uniform measurement to compare and discuss the performance of VO in terms of depth, feature extraction, and matching. The paper also provides a summary of complex and emerging areas of deep VO, including mobile robots, medical robots, augmented and virtual reality, and more, by analyzing and comparing relevant literature. Additionally, the authors suggest several open issues and propose future research directions in this field.

Vikas Thapa, Abhishek Sharma, Beena Gairola, Amit K. Mondal, Vindhya Devalla, Ravi k Patel [4]

In this paper, the authors provide an overview of contemporary visual odometry strategies, application challenges in mobile robots. This review includes a relative analysis of various accessible methods and algorithms, focusing on their performance and feature extraction capabilities, as well as the optimality of these methods. Vision-based odometry is identified as a robust and cost-effective approach among the available methods. Additionally, the authors highlight the effectiveness of combining feature estimation from odometry with interpretations of the environment using a mobile camera.

Davide Scaramuzza and Friedrich Fraundorfer[5]

In this paper, the author introduces the fundamental concept of visual odometry, which involves an agent's egomotion using data from one or more attached cameras. This technique finds applications in various domains such as robotics, wearable computing, augmented reality, and automotive. The author discusses the visual odometry problem and camera calibration and modeling techniques, including altitude, omnidirectional, and spherical camera models. Additionally, the paper covers various motion estimation techniques, such as triangulation, keyframe selection, 3D-to-2D motion estimation using shape and image feature correspondences, 2D-to-2D motion estimation using image feature correspondences, computing relative scale, and 3D-to-3D motion estimation using shape correspondences.

Shashi Poddar, Rahul Kottath ,Vinod Karar[6]

In this paper, the authors focus on the vehicle-based vision-based odometry method that utilizes a camera mounted on a vehicle to localize itself. The paper discusses the state-of-the-art visual odometry (VO) techniques, including their types, methods, uses, and challenges. It also compares VO with other popular localization tools such as laser sensors, global positioning systems, and inertial navigation systems. The authors highlight future research directions in various areas related to VO.

Mengshen Yang, Xu Sun ,Fuhua Jia, Adam Rushworth, Xin Dong, Sheng Zhang[7]: The authors of this paper provide a comprehensive analysis of various sensor modalities used for indoor odometry, including IMUs, LIDAR, radar, and cameras. They also explore the use of polymers in these sensors. The paper dwells into the algorithms and fusion frameworks in work for estimation of pose and odometry with the sensors. Overall, the authors offer a thorough review of the theory and application of indoor odometry, shedding light on the various aspects of the field.

Yaxuan Yan, Baohua Zhang, Jun Zhou, Yibo Zhang, Xiao'ang Liu[8]: The paper aims to develop a methodology for accurately estimating pose and generating dense 3D point cloud maps in complex greenhouse environments through the use of multi-sensor fusion and Visual-IMU-Wheel odometry. To achieve this, the proposed approach integrates measurements from wheel odometry, IMU, and VIO sensors in a loosely coupled framework based on the EKF. Extensive experiments were conducted in both greenhouse and outdoor environments to tackle various navigation challenges. The results reveal that the proposed framework significantly improves the VIO system's localization accuracy, indicating its potential for autonomous navigation in the agricultural industry.

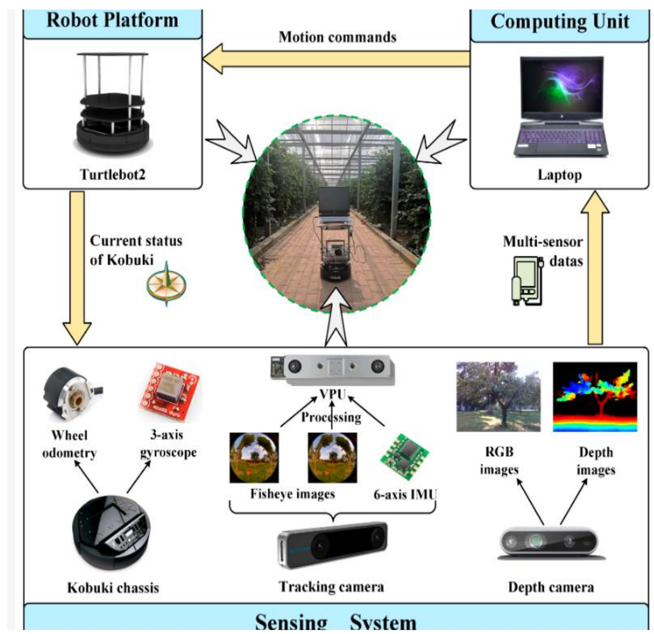

Fig. 1. Sensing System[8]

Mert Gurturk , Abdullah Yusefi , Muhammet Fatih Aslan, Metin Soycan, Akif Durdu, Andrea Masiero[9]: The paper introduces a publicly available dataset that researchers can use in SLAM investigations. The dataset was collected using a terrestrial vehicle at the outdoor location of Yildiz Technical University, and the acquisition system included two calibrated and synchronized cameras, an IMU, and two GPS receivers. To demonstrate the dataset's usefulness, the authors applied VIO to the KITTI dataset and proposed a new VIO method based on a recurrent neural network, which was compared with ORB-SLAM2 and OKVIS approaches. The paper presents experimental results that validate the proposed

VIO method's effectiveness. The dataset is a valuable resource for researchers in the field of SLAM, and the new recurrent neural network-based approach to VIO has the potential to enhance the accuracy of pose estimation.

Julian Nubert, Shehryar Khattak, Marco Hutter[10]: This paper proposes a flexible self-supervised method for estimating LIDAR odometry that enables efficient utilization of LIDAR data while maintaining real-time performance. The approach incorporates geometric losses during training, considering the amount of information that can be extracted from experimental factors. Furthermore, the network architecture presented in this study is adaptable to different environments and sensor modalities without requiring adjustments to the network or loss functions. The proposed approach is evaluated extensively for indoor and outdoor applications using legged, tracked, and wheeled robots. The results demonstrate that the proposed learning-based LIDAR odometry approach is well-suited for complex robotic systems.

Murdoch, David[11]: This paper proposes VIL-DSO, a visual odometry approach that combines various algorithms to improve pose estimation and provide metric scale. The paper also presents a method for automatically determining an accurate physical transformation between radar and camera data, which allows for the projection of radar data onto the image plane. Additionally, the paper introduces EVIL-DSO, a localization method that fuses visual-inertial odometry with radar data. The contributions of this work include improvements in pose estimation, metric scale, and localization accuracy through the combination of multiple algorithms and the integration of radar data.

III. CONCLUSION

This paper provides a literature survey of odometry techniques for robotics applications. Various papers are reviewed to provide a comprehensive understanding of visual odometry, including state estimation algorithms for different sensors such as inertial measurement sensors, cameras, LIDAR, and radar, as well as the use of polymeric materials in these sensors. The paper also proposes a new real-time strategy for dynamic localization and mapping ,GPS-denied greenhouse environments, which integrates wheel odometry measurements. Another approach discussed in the paper involves augmenting visual odometry with radar information, resulting in the EVIL-DSO algorithm. The paper includes a review and description of various techniques and methods found in the literature.

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