Technical Review on Ballistocardiography OR IMU OR (Ballistocardiogram AND Accelerometer)

Introduction

This document provides a technical review of recent research papers on the combined use of Ballistocardiography (BCG) and Inertial Measurement Units (IMUs).

Research Papers

Mojito: LLM-Aided Motion Instructor with Jitter-Reduced Inertial Tokens

- **Authors:** Ziwei Shan, Yaoyu He, Chengfeng Zhao, Jiashen Du, Jingyan Zhang, Qixuan Zhang, Jingyi Yu, Lan Xu
- **Published:** 2025-02-22
- **arXiv ID:** 2502.16175v1
- **URL:** http://arxiv.org/pdf/2502.16175v1
- **Categories:** cs.CV, cs.AI, cs.GR
- **Summary:** Human bodily movements convey critical insights into action intentions and cognitive processes, yet existing multimodal systems primarily focused on understanding human motion via language, vision, and audio, which struggle to capture the dynamic forces and torques inherent in 3D motion. Inertial measurement units (IMUs) present a promising alternative, offering lightweight, wearable, and privacy-conscious motion sensing. However, processing of streaming IMU data faces challenges such as wireless transmission instability, sensor noise, and drift, limiting their utility for long-term real-time motion capture (MoCap), and more importantly, online motion analysis. To address these challenges, we introduce Mojito, an intelligent motion agent that integrates inertial sensing with large language models (LLMs) for interactive motion capture and behavioral analysis.

FIP: Endowing Robust Motion Capture on Daily Garment by Fusing Flex and Inertial Sensors

- **Authors:** Jiawei Fang, Ruonan Zheng, Yuanyao, Xiaoxia Gao, Chengxu Zuo, Shihui Guo, Yiyue Luo
- **Published:** 2025-02-20
- **arXiv ID:** 2502.15058v1
- **URL:** http://arxiv.org/pdf/2502.15058v1
- **Categories:** cs.HC
- **Summary:** What if our clothes could capture our body motion accurately? This paper introduces Flexible Inertial Poser (FIP), a novel motion-capturing system using daily garments with two elbow-attached flex sensors and four Inertial Measurement Units (IMUs). To address the inevitable sensor displacements in loose wearables which degrade joint tracking accuracy significantly, we identify the distinct characteristics of the flex and inertial sensor displacements and develop a Displacement Latent Diffusion Model and a Physics-informed Calibrator to compensate for sensor displacements based on such observations, resulting in a substantial improvement in motion capture accuracy. We also introduce a Pose Fusion Predictor to enhance multimodal sensor fusion. Extensive

experiments demonstrate that our method achieves robust performance across varying body shapes and motions, significantly outperforming SOTA IMU approaches with a 19.5% improvement in angular error, a 26.4% improvement in elbow angular error, and a 30.1% improvement in positional error. FIP opens up opportunities for ubiquitous human-computer interactions and diverse interactive applications such as Metaverse, rehabilitation, and fitness analysis.

The NavINST Dataset for Multi-Sensor Autonomous Navigation

- **Authors:** Paulo Ricardo Marques de Araujo, Eslam Mounier, Qamar Bader, Emma Dawson, Shaza I. Kaoud Abdelaziz, Ahmed Zekry, Mohamed Elhabiby, Aboelmagd Noureldin
- **Published:** 2025-02-19
- **arXiv ID:** 2502.13863v1
- **URL:** http://arxiv.org/pdf/2502.13863v1
- **Categories:** cs.RO
- **Summary:** The NavINST Laboratory has developed a comprehensive multisensory dataset from various road-test trajectories in urban environments, featuring diverse lighting conditions, including indoor garage scenarios with dense 3D maps. This dataset includes multiple commercial-grade IMUs and a high-end tactical-grade IMU. Additionally, it contains a wide array of perception-based sensors, such as a solid-state LiDAR - making it one of the first datasets to do so - a mechanical LiDAR, four electronically scanning RADARs, a monocular camera, and two stereo cameras. The dataset also includes forward speed measurements derived from the vehicle's odometer, along with accurately post-processed high-end GNSS/IMU data, providing precise ground truth positioning and navigation information. The NavINST dataset is designed to support advanced research in high-precision positioning, navigation, mapping, computer vision, and multisensory fusion. It offers rich, multi-sensor data ideal for developing and validating robust algorithms for autonomous vehicles. Finally, it is fully integrated with the ROS, ensuring ease of use and accessibility for the research community. The complete dataset and development tools are available at https://navinst.github.io.

GS-GVINS: A Tightly-integrated GNSS-Visual-Inertial Navigation System Augmented by 3D Gaussian Splatting

- **Authors:** Zelin Zhou, Saurav Uprety, Shichuang Nie, Hongzhou Yang
- **Published:** 2025-02-16
- **arXiv ID:** 2502.10975v1
- **URL:** http://arxiv.org/pdf/2502.10975v1
- **Categories:** cs.RO, cs.CV, eess.IV
- **Summary:** Recently, the emergence of 3D Gaussian Splatting (3DGS) has drawn significant attention in the area of 3D map reconstruction and visual SLAM. While extensive research has explored 3DGS for indoor trajectory tracking using visual sensor alone or in combination with Light Detection and Ranging (LiDAR) and Inertial Measurement Unit (IMU), its integration with GNSS for large-scale outdoor navigation remains underexplored. To address these concerns, we proposed GS-GVINS: a tightly-integrated GNSS-Visual-Inertial Navigation System augmented by 3DGS. This system leverages 3D Gaussian as a continuous differentiable scene representation in largescale outdoor environments, enhancing navigation performance through the constructed 3D Gaussian map. Notably, GS-GVINS is the first GNSS-Visual-Inertial navigation application that directly utilizes the analytical jacobians of SE3 camera pose with respect to 3D Gaussians. To maintain the quality of 3DGS rendering in extreme dynamic states, we introduce a motionaware 3D Gaussian pruning mechanism, updating the map based on relative pose translation and the accumulated opacity along the camera ray. For validation,

we test our system under different driving environments: open-sky, sub-urban, and urban. Both self-collected and public datasets are used for evaluation. The results demonstrate the effectiveness of GS-GVINS in enhancing navigation accuracy across diverse driving environments.

SpellRing: Recognizing Continuous Fingerspelling in American Sign Language using a Ring

- **Authors:** Hyunchul Lim, Nam Anh Dang, Dylan Lee, Tianhong Catherine Yu, Jane Lu, Franklin Mingzhe Li, Yiqi Jin, Yan Ma, Xiaojun Bi, François Guimbretière, Cheng Zhang
- **Published:** 2025-02-15
- **arXiv ID:** 2502.10830v1
- **URL:** http://arxiv.org/pdf/2502.10830v1
- **Categories:** cs.HC
- **Summary:** Fingerspelling is a critical part of American Sign Language (ASL) recognition and has become an accessible optional text entry method for Deaf and Hard of Hearing (DHH) individuals. In this paper, we introduce SpellRing, a single smart ring worn on the thumb that recognizes words continuously fingerspelled in ASL. SpellRing uses active acoustic sensing (via a microphone and speaker) and an inertial measurement unit (IMU) to track handshape and movement, which are processed through a deep learning algorithm using Connectionist Temporal Classification (CTC) loss. We evaluated the system with 20 ASL signers (13 fluent and 7 learners), using the MacKenzie-Soukoref Phrase Set of 1,164 words and 100 phrases. Offline evaluation yielded top-1 and top-5 word recognition accuracies of 82.45% (9.67%) and 92.42% (5.70%), respectively. In real-time, the system achieved a word error rate (WER) of 0.099 (0.039) on the phrases. Based on these results, we discuss key lessons and design implications for future minimally obtrusive ASL recognition wearables.

Summary of Findings

Recent research explores the intersection of Ballistocardiography (BCG) and Inertial Measurement Units (IMUs). Studies focus on mojito [1, 1]. Studies focus on aided motion [1]. Studies focus on instructor [1]. Studies focus on jitter [1]. Studies focus on reduced inertial [1]. Studies focus on tokens [1]. Studies focus on human [1]. Studies focus on inertial [1, 2, 4, 4]. Studies focus on us [1, 2, 3]. Studies focus on however [1]. Studies focus on mo [1]. Studies focus on cap [1]. Studies focus on ms [1]. Studies focus on endowing robust [2]. Studies focus on motion capture [2]. Studies focus on daily garment [2]. Studies focus on fusing flex [2]. Studies focus on inertial sensors [2]. Studies focus on what [2]. Studies focus on this [2, 3, 4]. Studies focus on flexible inertial [2]. Studies focus on poser [2]. Studies focus on measurement units [2]. Studies focus on displacement latent [2]. Studies focus on diffusion model [2]. Studies focus on physics [2]. Studies focus on calibrator [2]. Studies focus on we [2, 5]. Studies focus on pose fusion [2]. Studies focus on predictor [2]. Studies focus on extensive [2]. Studies focus on metaverse [2]. Studies focus on the nav [3, 3, 3]. Studies focus on dataset [3]. Studies focus on multi [3]. Studies focus on sensor autonomous [3]. Studies focus on navigation [3]. Studies focus on laboratory [3]. Studies focus on additionally [3]. Studies focus on li [3, 3, 4]. Studies focus on rs [3]. Studies focus on it [3]. Studies focus on finally [3]. Studies focus on tightly [4]. Studies focus on visual [4, 4, 4]. Studies focus on inertial navigation [4, 4]. Studies focus on system augmented [4]. Studies focus on gaussian splatting [4, 4]. Studies focus on recently [4]. Studies focus on while [4]. Studies focus on light detection [4]. Studies focus on ranging [4]. Studies focus on measurement unit [4]. Studies focus on system [4]. Studies focus on gaussian [4, 4, 4]. Studies focus on notably [4]. Studies focus on gaussians [4]. Studies focus on both [4]. Studies focus on spell [5, 5, 5]. Studies focus on ring [5, 5, 5, 5]. Studies focus on recognizing continuous [5]. Studies focus on fingerspelling [5, 5]. Studies focus on american sign [5, 5]. Studies focus on language [5, 5]. Studies focus on deaf [5]. Studies focus on hard [5]. Studies focus on hearing [5]. Studies focus on connectionist temporal [5]. Studies focus on classification [5]. Studies focus on mac [5]. Studies focus on kenzie [5]. Studies focus on soukoref phrase [5]. Studies focus on set [5]. Studies focus on offline [5]. Studies focus on based [5].