

RIDI: Robust IMU Double Integration

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Abstract. This paper proposes a novel data-driven approach for inertial navigation, which learns to estimate trajectories of natural human motions just from an inertial measurement unit (IMU) in every smart-phone. The key observation is that human motions are repetitive and consist of a few major modes (e.g., standing, walking, or turning). Our algorithm regresses a velocity vector from the history of linear accelerations and angular velocities, then corrects low-frequency bias in the linear accelerations, which are integrated twice to estimate positions. We have acquired training data with ground truth motion trajectories across multiple human subjects and multiple phone placements (e.g., in a bag or a hand). The qualitative and quantitative evaluations have demonstrated that our simple algorithm outperforms existing heuristic-based approaches and is even comparable to full Visual Inertial navigation to our surprise. As far as we know, this paper is the first to introduce supervised training for inertial navigation, potentially opening up a new line of research in the domain of data-driven inertial navigation. We will publicly share our code and data to facilitate further research.⁴

1 Introduction

Accurate position estimation from an Inertial Measurement Unit (IMU) has long been a dream in academia and industry. IMU double integration is an approach with a simple principle: given a device rotation (e.g., from IMU), one measures an acceleration, subtracts the gravity, integrates the residual acceleration once to get velocities, and integrates once more to get positions. Dead-reckoning or step counting is another approach, which detects foot-steps to estimate the distance of travel and utilizes device rotations to estimate motion directions. IMU is in every smart-phone, is very energy-efficient (i.e., capable of running 24 hours a day), and works anywhere even inside a bag or a pocket. A robust inertial navigation would be an ultimate anytime anywhere navigation system.

Unfortunately, the current state-of-the-art suffers from severe limitations. First, IMU double integration does not work unless one uses a million dollar

⁴ Project website: <https://yanhangpublic.github.io/ridi>

