InternPro Weekly Progress Update

Name	Email	Project Name	NDA/ Non-NDA	InternPro Start Date	OPT
Adharsh Prasad Natesan	anatesan@asu.edu	IT-Core Foundation Suriname	Non-NDA	2024-08-05	Yes

Progress

Include an itemized list of the tasks you completed this week.

#	Action Item/ Explanation	Total Time This Week (hours)
1	Research on adopting GNSS/IMU for Agriculture	3
2	GNSS/RTK for Precision Agriculture	3
3	Research paper on Visual Odometry Positioning	3
4	AGRI-SLAM for agricultural environment	3
5	Research on overview of PPP-RTK	3
6	Simulating GNSS RTK virtually(Matlab/ROS)	2
7	Weekly Report	3
	Total hours for the week:	20

Verification Documentation:

Action Item 1: Research on adopting GNSS/IMU for Agriculture – 3 hour(s).

Research

- https://www.mdpi.com/2077-0472/13/7/1417

- Global Navigation Satellite Systems as State-of-the-Art Solutions in Precision Agriculture: A Review of Studies Indexed in the Web of Science
- Summary of Report
  - Provides a comprehensive review of GNSS applications in precision agriculture based on Web of Science literature.
  - Examines trends in GNSS research for agriculture, highlighting emerging areas like multi-constellation receivers and precise point positioning.
  - Covers both remote sensing and computer processing-based solutions that utilize GNSS for precise positioning and mapping in agricultural contexts.
- Relation to Project
  - Multi-constellation receivers improve positioning accuracy and signal availability, crucial for precise robot navigation in fields.
  - This paper covers the integration of GNSS with IMUs for positioning accuracy and robustness, especially for dynamic agricultural machinery operations.
  - Precise Point Positioning (PPP) provides centimeter-level accuracy using a single GNSS receiver, the accuracy which we are aiming for.
- Motivation for Research
  - Last week, I explored various techniques for positioning agricultural robots. This week, I plan to dive deeper into the implementation of each technique in agriculture.
  - Precise positioning is essential for various precision agriculture applications, including autonomous navigation and variable rate technology.
  - Improved positioning accuracy enables more efficient and sustainable farming practices, reducing input costs and environmental impact

Action Item 2: GNSS/RTK for Precision Agriculture – 3 hour(s).

Research

- https://www.mdpi.com/2073-4395/10/7/924
- Positioning Accuracy Comparison of GNSS Receivers Used for Mapping and Guidance of Agricultural Machines
- Summary of Report
  - The study compares the positioning accuracy of four GNSS receivers with different technical features and working modes for agricultural applications.
  - The receivers tested include dual-frequency (L1/L2) and single-frequency (L1) models, with and without Real-Time Kinematic (RTK) capabilities.
  - Various tests were conducted, evaluating the impact of RTK differential correction and external antennas on positioning accuracy.
- Relation to Project
  - Provides insights into the performance of different GNSS receiver types relevant to precision agriculture applications.
  - Evaluates the impact of RTK and external antennas on positioning accuracy, which is crucial for autonomous agricultural robots.
  - Offers data on low-cost GNSS options, which could be relevant for developing affordable farming technology.
- Motivation for Research
  - Since GNSS/IMU was covered in the previous paper, this paper now delves into understanding how GNSS/RTK is implemented for positioning.
  - To assess the importance of RTK and external antennas in

achieving high positioning accuracy for agricultural applications.
    - To explore cost-effective GNSS solutions that could potentially be integrated into the FarmBot project.

Action Item 3: Research paper on Visual Odometry Positioning – 3 hour(s).

Research

- https://www.sciencedirect.com/science/article/abs/pii/S1537511016305189?via%3Dihub
- Analysis of two visual odometry systems for use in an agricultural field environment
- Summary of Report
    - The paper evaluates the impact of various design parameters and camera setups using simulations and real field experiments.
    - The authors have conducts four real field experiments using a mobile robot in agricultural settings, covering distances of 1.8-3.1 km.
    - The papers analyze the performance of downward-facing and forward-facing camera setups and investigates the effects of camera angle, resolution, and frame rate on VO accuracy.
- Relation to Project
    - Provides insights into optimal camera setups for visual odometry in agricultural environments.
    - The paper offers data on the performance of VO systems in real-world agricultural conditions.
    - Compares two state-of-the-art VO algorithms (Gantry and Libviso methods) for the agricultural robotic positioning,
    - Discusses the challenges of estimating 6-DOF position in agricultural fields, particularly roll and pitch.
- Motivation for Research
    - To improve the accuracy and robustness of visual odometry systems for agricultural robots.
    - To understand the impact of various design parameters on VO performance in field conditions.
    - To evaluate the suitability of different VO algorithms for agricultural applications.
    - To address the limitations of current GPS-based navigation systems in agricultural settings.

Action Item 4: AGRI-SLAM for agricultural environment – 3 hour(s).

Research

- https://link.springer.com/article/10.1007/s10514-023-10110-y
- AGRI-SLAM: a real-time stereo visual SLAM for agricultural environment
- Summary of Report
    - The paper proposes a stereo visual SLAM system optimized for localization and mapping in agricultural environments.
    - The proposed methodology incorporates image enhancement techniques to improve feature detection in low-light and hazy conditions.
    - The authors combines point (ORB) and line (LSD) features for more robust performance in agricultural settings.
- Relation to Project
    - Provides a solution in difficult situations like GPS-denied localization under tree canopies.

    - The paper demonstrates improved performance over existing SLAM methods in low-light/hazy conditions.
    - The paper also addresses the SLAM challenges in implementing for agricultural environments.
- Motivation for Research
    - The paper enables autonomous navigation of agricultural robots in difficult terrains like GPS-denied environments.
    - It also provides a way to improve SLAM robustness to challenging lighting conditions common in agriculture.
    - Develop SLAM techniques tailored specifically for agricultural applications and environments.

Action Item 5: Research on overview of PPP-RTK – 3 hour(s).

Research

- https://satellite-navigation.springeropen.com/articles/10.1186/s43020-022-00089-9
- Review of PPP–RTK: achievements, challenges, and opportunities
- Summary of Report
    - Provides a comprehensive review of PPP-RTK technology, including implementation methods, recent achievements, and challenges.
    - The paper discusses key techniques like UPD estimation, atmospheric correction modeling, and fast ambiguity resolution.
    - Examines PPP-RTK applications and performance in various scenarios, including multi-GNSS, multi-frequency, and vehicle navigation
- Relation to Project
    - Offers an overview of state-of-the-art PPP-RTK methods which is relevant to precise positioning for agricultural robotics.
    - Discusses integration of PPP-RTK with other sensors like INS, which could be applicable for robotic navigation.
    - Highlights challenges like atmospheric modeling that may hinder in the achieving accuracy for agricultural environments.
- Motivation for Research
    - I wanted to learn about RTK methodology in general, so that I could better be able to apply for the agricultural application.
    - To understand the current capabilities and limitations of PPP-RTK for centimeter-level positioning.
    - To identify key technical challenges that need to be addressed for wider PPP-RTK adoption.

Action Item 6: Simulating GNSS RTK virtually(Matlab/ROS) – 2 hour(s).

Weekly Work

- Research and identify key MATLAB resources:
    - Explored various GNSS toolboxes and open-source projects for MATLAB
    - Identified relevant functions and code examples for RTK simulation
    - Compiled a list of useful MATLAB resources for GNSS/RTK modeling.

Action Item 7: Weekly Report – 3 hour(s).

Project Work Summary

- Documented the research papers, review papers and relevant links that were inferred from both the literature review and GNSS simulation software.
- Went deeper into how all the current techniques available for positioning of rovers is working and applied for the agriculture individually.
- Then prepared a plan to simulate the GNSS RTK entirely through software and try gain to better understanding by simulation.
- Enlisted things to do for next week aligning with the plan to develop a GNSS RTK simulation environment in MATLAB.
- Then created relevant subsections in the epicspro website and documented 20 hours of weekly progress.