

Radhika Ravi

Ph.D. Candidate in Civil Engineering (Geomatics)

Personal Webpage: <http://web.ics.purdue.edu/~ravi22>

Phone No.: +1 765 476 6183, E-mail ID: ravi22@purdue.edu

research interests

- **Calibration** of Airborne and Terrestrial **Mobile Mapping Systems** comprising LiDAR Units and Cameras;
- LiDAR and Imagery-assisted **GNSS/INS Trajectory Refinement**;
- Automatic Feature Extraction and Object Detection from **LiDAR and Photogrammetric Data**

education

Doctor of Philosophy

Advisor: Prof. Ayman Habib

Lyles School of Civil Engg., Purdue University
(2019–Present)

Master of Science in Civil Engg. (Thesis-based)

Advisor: Prof. Ayman Habib

Lyles School of Civil Engg., Purdue University
(2016–2019)

Bachelor of Technology, Dual Majors

Dept. of Civil Engg. & Dept. of Electrical Engg.

Indian Institute of Technology Kanpur
(2011–2016)

work experience

Lyles Teaching Fellow, Aug'20–Present

CE 203: Principles and Practice of Geomatics

Lyles School of Civil Engg., Purdue University

Graduate Research Assistant, Jan'17–Jul'20

Digital Photogrammetry Research Group (DPRG)

Lyles School of Civil Engg., Purdue University

Graduate Teaching Assistant, Aug–Dec'16

Recitation Instructor for Calculus-1

Dept. of Mathematics, Purdue University

publications

Peer-reviewed Journal Papers

Ravi, R., Habib, A. (2020). Fully Automated Profile-based Calibration Strategy for Airborne and Terrestrial Mobile LiDAR Systems with Spinning Multi-beam Laser Units. *Remote Sensing*, 12(3), 401.

Zhou, T., Hasheminasab, S. M., **Ravi, R.**, Habib, A. (2020). LiDAR-Aided Interior Orientation Parameters Refinement Strategy for Consumer-Grade Cameras Onboard UAV Remote Sensing Systems. *Remote Sensing*, 12(14), 2268.

Lin, Y. C., Cheng, Y. T., Zhou, T., **Ravi, R.**, Hasheminasab, S. M., Flatt, J. E., Troy, C., Habib, A. (2019). Evaluation of UAV LiDAR for Mapping Coastal Environments. *Remote Sensing*, 11(24), 2893.

Ravi, R., Cheng, Y. T., Lin, Y. C., Lin, Y. J., Hasheminasab, S. M., Zhou, T., Flatt, J.E., Habib, A. (2019). Lane Width Estimation in Work Zones Using LiDAR-Based Mobile Mapping Systems. *IEEE Transactions on Intelligent Transportation Systems*.

Ravi, R., Shamseldin, T., Elbahnasawy, M., Lin, Y.J., Habib, A. (2018). Bias Impact Analysis and Calibration of UAV-Based Mobile LiDAR System with Spinning Multi-Beam Laser Scanner. *Applied Sciences*, 8(2), 297.

Ravi, R., Lin, Y.J., Elbahnasawy, M., Shamseldin, T., Habib, A. (2018). Simultaneous System Calibration of a Multi-LiDAR Multicamera Mobile Mapping Platform. *IEEE Journal of Selected Topics in Applied Earth Observations*

and Remote Sensing, 11(5), 1694-1714.

Ravi, R., Lin, Y. J., Elbahnasawy, M., Shamseldin, T., Habib, A. (2018). Bias Impact Analysis and Calibration of Terrestrial Mobile LiDAR System with Several Spinning Multibeam Laser Scanners. *IEEE Transactions on Geoscience and Remote Sensing*, 56(9), 5261-5275.

Peer-reviewed Conference Papers

Ravi, R., Habib, A., Bullock, D. (2020). Pothole Mapping and Patching Quantity Estimates using LiDAR-Based Mobile Mapping Systems. *Transportation Research Record*, doi:10.1177/0361198120927006.

Ravi, R., Bullock, D., Habib, A. (2020). Highway and Airport Runway Pavement Inspection using Mobile LiDAR. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 43, 349-354.

Ravi, R., Habib, A. (2019, May). Image-LiDAR Interactive Visualization Environment (I-LIVE) for Mobile Mapping Systems. In *Proceedings of the 11th International Symposium on Mobile Mapping Technology*, May 6-8, Shenzhen, China.

Cheng, Y.T., Lin, Y.C., **Ravi, R.**, Habib, A. (2019, May). Detection and Visualization of Narrow Lane Regions in Work Zones Using LiDAR-based Mobile Mapping Systems. In *Proceedings of the 11th International Symposium on Mobile Mapping Technology*, May 6-8, Shenzhen, China.

Ravi, R., Hasheminasab, S.M., Zhou, T., Masjedi, A., Quijano, K., Flatt, J.E., Crawford, M., Habib, A. (2019, May). UAV-based multi-sensor multi-platform integration for high throughput phenotyping. In *Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping IV* (Vol. 11008, p. 110080E), Baltimore, MD, USA. International Society for Optics and Photonics.

Ravi, R., Lin, Y. J., Shamseldin, T., Elbahnasawy, M., Masjedi, A., Crawford, M., Habib, A. (2018, July). Wheel-Based LiDAR Data for Plant Height and Canopy Cover Evaluation to Aid Biomass Prediction. In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium* (pp. 3242-3245), Valencia, Spain. IEEE.

Ravi, R., Lin, Y. J., Shamseldin, T., Elbahnasawy, M., Crawford, M., Habib, A. (2018, July). Implementation of UAV-Based Lidar for High Throughput Phenotyping. In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium* (pp. 8761-8764), Valencia, Spain. IEEE.

Shamseldin, T., **Ravi, R.**, Elbahnasawy, M., Lin, Y. J., Habib, A. (2018, July). Bias Impact Analysis and Calibration of UAV-Based Mobile Lidar System. In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium* (pp. 8769-8772), Valencia, Spain. IEEE.

Elbahnasawy, M., Shamseldin, T., **Ravi, R.**, Zhou, T., Lin, Y. J., Masjedi, A., Flatt, J.E., Crawford, M., Habib, A. (2018, July). Multi-sensor integration onboard a UAV-based mobile mapping system for agricultural management. In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium* (pp. 3412-3415), Valencia, Spain. IEEE.

Lin, Y.J., **Ravi, R.**, Shamseldin, T., Elbahnasawy, M., Bullock, D., Habib, A. (2016). Comparative Analysis of Potential Calibration Alternatives for a Multi-unit LiDAR System. In *Proceedings of the 10th International Symposium on Mobile Mapping Technology*, May 6-8, Cairo, Egypt.

Technical Reports

Habib, A., Lin, Y.J., **Ravi, R.**, Shamseldin, T., Elbahnasawy, M. (2018). LiDAR-based Mobile Mapping System for Lane Width Estimation in Work Zones (Joint Transportation Research Program). West Lafayette, IN: Purdue University.

Thesis

Ravi, R. (2019). Interactive Environment For The Calibration And Visualization Of Multi-sensor Mobile Mapping Systems (Masters Thesis, Purdue University Graduate School).

research experience

- LiDAR; Transportation **Highway and Airport Runway Pavement Inspection using Mobile LiDAR** Jan'20–Aug'20
Mentor: Prof. Ayman Habib
- Proposed a unique algorithm for above-ground and below-ground anomaly detection over pavement surfaces using mobile LiDAR-based 3D point clouds
 - Demonstrated the efficiency of the algorithm for pothole detection over highways and foreign object debris (FOD) detection over airport runways
 - Proved the ability of the algorithm for a 100% detection of potholes and debris that are over 2 cm in dimensions
- LiDAR; Photogrammetry; Environmental Monitoring **Evaluation of UAV LiDAR for Mapping Coastal Environments** Aug'18–Nov'19
Mentor: Prof. Ayman Habib
- Compared image-based and LiDAR-based mapping over different geomorphic environments in terms of their point density, relative and absolute accuracy, and area coverage
 - Assessed UAV LiDAR-based data for applicability in monitoring shoreline recession over two actively eroding sandy beaches in Indiana
 - Used the resultant shoreline volume loss estimates over a one-year period and a storm-induced period to highlight the importance of episodic events in coastline changes
- LiDAR **Fully Automated Profile-based Calibration Strategy for Airborne and Terrestrial Mobile LiDAR Systems with Spinning Multi-beam Laser Units** Aug'19–Dec'19
Mentor: Prof. Ayman Habib
- Proposed a fully automated targetless calibration strategy to estimate mounting parameters between LiDAR and GNSS/INS unit
 - Validated the proposed strategy by calibrating several airborne and terrestrial LiDAR systems and comparing the results to those from previously existing feature-based calibration strategy
 - Proved the ability of proposed strategy to reduce misalignment in LiDAR-based point clouds to less than 2 cm
- LiDAR; Transportation **Pothole Mapping and Patching Quantity Estimates using LiDAR-based Mobile Mapping Systems** Oct'18–Aug'19
Mentor: Prof. Ayman Habib
- Compared the accuracy of 3D point cloud from medium-grade (Velodyne) and high-grade (Riegl/ZF) MMS for pothole detection
 - Developed an algorithm to detect and classify potholes along transportation corridors based on their severity using LiDAR point cloud from a mobile mapping system
 - Clustered and traced the boundary of potholes using region-growing and minimum convex hull approach
 - Built a software for visualization of reported pothole points in 3D point cloud as well as their boundaries in 2D RGB imagery
- LiDAR; Transportation **Lane Width Estimation in Work Zones using LiDAR-based Mobile Mapping Systems** Aug'18–Oct'19
Mentor: Prof. Ayman Habib
- Proposed a methodology for lane width estimation using LiDAR point cloud from a mobile mapping system
 - Developed an algorithm to detect and report areas with ambiguous lane markings, narrow lanes, and/or wide lanes
 - Built a software for the visualization of reported areas in 3D point cloud as well as 2D RGB imagery

LiDAR; Agriculture	<p>Wheel-based and UAV-based LiDAR Data for Plant Height and Canopy Cover Estimation to aid High Throughput Phenotyping <i>Mentors: Prof. Ayman Habib, Prof. Melba Crawford</i> Aug'17–May'18</p> <ul style="list-style-type: none"> – Generated Crop Surface Models (CSMs) at 30th, 60th, and 90th percentile heights to evaluate the ability of system to penetrate the plant structure – Combined CSMs with a Digital Terrain Model (DTM) to obtain the canopy cover for each plot in an agricultural field – Obtained the time-series plant height and canopy cover estimates for several genotypes in order to utilize the phenotypic traits for biomass prediction
LiDAR	<p>Bias Impact Analysis and Development of Optimal Flight-line Configuration for Calibration of UAV-based Mobile Mapping Systems <i>Mentor: Prof. Ayman Habib</i> Aug'17–Feb'18</p> <ul style="list-style-type: none"> – Conducted a theoretical analysis of 3D LiDAR point positioning equation to estimate the potential impact of bias in mounting parameters of a LiDAR unit (onboard a UAV) on resultant point cloud – Devised an optimal flight-line configuration for an efficient calibration and designed experiments to validate the accuracy of calibration
LiDAR; Photogrammetry	<p>MS Thesis: Interactive Environment for the Calibration and Visualization of Multi-sensor Mobile Mapping Systems <i>Primary Advisor: Prof. Ayman Habib;</i> <i>Committee Members: Prof. Melba Crawford, Prof. Wolfgang Förstner</i> Jan'17–Jul'18</p> <p>Bias Impact Analysis:</p> <ul style="list-style-type: none"> – Analyzed the potential impact of bias in mounting parameters of a LiDAR unit on resultant point cloud – Established an optimal target primitive and drive-run configuration for most accurate calibration – Developed an outdoor multi-unit LiDAR system calibration procedure for a terrestrial mobile mapping platform <p>Multi-LiDAR Multi-Camera System Calibration:</p> <ul style="list-style-type: none"> – Extended the calibration procedure to use conjugate points and geometric features to calibrate multi-LiDAR multi-camera systems onboard airborne or terrestrial mobile platform – Experimentally evaluated the proposed technique by calibrating several mobile mapping platforms with varying number of LiDAR units and cameras <p>Image-LiDAR Interactive Visualization Environment (I-LIVE): UI integrated with Cloud-Compare</p> <ul style="list-style-type: none"> – Facilitates the visualization of point clouds, imagery data, and their registration quality – Aids the qualitative evaluation of calibration results for a generic mobile mapping system – Tool for qualitative quality control of GNSS/INS-derived trajectory and LiDAR-camera system calibration – Allows forward and backward projections to/from LiDAR and imagery data – Equipped with several tools to aid image and LiDAR-based transportation and agricultural applications
LiDAR; Urban Modeling	<p>Reconstruction of Complex Digital Building Models from LiDAR Point Clouds through a Tightly-integrated Recursive Minimum Bounding Rectangle and Least Squares Adjustment Procedure <i>Mentor: Prof. Ayman Habib</i> Jan–Aug'17</p> <ul style="list-style-type: none"> – Devised a strategy for modeling of buildings from airborne LiDAR point cloud data using Recursive Minimum Bounding Rectangle (RMBR) and Least Squares Adjustment (LSA) – Developed and validated (using experiments) a water-tight building model strategy to remove gaps between contiguous building models

Computer Vision	Implementation of Obstacle Navigation System for Visually Impaired People using Stereo Vision <i>Mentors: Prof. Bharat Lohani, Prof. K. S. Venkatesh</i> <ul style="list-style-type: none"> – Implemented 3D Data Acquisition System using two web-cameras and Stereo-Vision Algorithms – Coded the entire framework in C++ using OpenCV to isolate the closest obstacle and convey distance information through amplitude of sound 	Jan-Dec'15
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relevant projects

Thumb Rule to Locate Optimal Point of Observation to Determine Tower Height Using REM (Remote Elevation Measurement) Technique

Jan-Dec'14

Mentor: Prof. Bharat Lohani

Performed Analytical Computations, MATLAB Simulations, Field Experiments and analysis using Genetic Algorithm to invent a method to increase the accuracy in measuring the height of high-rise towers and suggested a thumb rule to determine position of observation

Knock! Knock! Who is it?" Probabilistic Person Identification in TV-Series

Jan-Apr'16

Mentor: Prof. Vinay P. Namboodiri

Implemented the paper by *M Tapaswi et al. (2012)*; Executed different algorithms for scene and shot change detection in an episode, face detection and tracking, and clothing detection in the video; Integrated these results in a probabilistic manner to identify and tag the person(s) in each frame

Data Hiding using Discrete Wavelet Transform (DWT) based Steganography

Aug-Dec'15

Mentor: Prof. Sumana Gupta

Used OpenCV to implement DWT based Steganography to maximise embedded confidential data (invisible to human perception) and protect the data from external attacks: Rotation, Cropping, Scratching of image

Statistical Analysis of Multispectral Images in MATLAB

Aug-Dec'14

Mentor: Prof. Bharat Lohani

Computed the OIF for two multispectral images from LANDSAT 8 and WorldView 2; Identified the best 3-band combination in each image for identification and extraction of various features present in the region of interest

Nesting Algorithm to Optimize the Layout of Slices of 3D Model in 123D Make Software (Autodesk)

May-Jul'14

Organisation: Autodesk India (Full-time Internee)

Developed algorithms to slice a 3D model and lay out the irregularly shaped slices on 2D Sheets with minimal wastage of material (filling holes and adjusting notches) and in minimal amount of time (unlike heuristic algorithms)

relevant courses

Geomatics

Surveying and Geoinformatics
Adjustment of Geospatial Observations
Laser Scanning
Digital Photogrammetric Systems
Multi and Hyperspectral Remote Sensing
GNSS/INS Integration

Mathematics

Linear Algebra and Its Applications
Calculus
Probability and Statistics
Partial Differential Equations
Random Variables
Applied Multivariate Analysis
Design of Experiment

Computer Science

Machine Learning
Computer Vision and Image Processing
Deep Learning; Deep Learning in Machine Vision
Data Structures and Algorithms
Data Mining and Knowledge Extraction
Programming Parallel Machines

Electrical Engineering

Optimization Methods for System and Control
Digital and Statistical Signal Processing
Digital Electronics
Principles of Communication
Mathematical Structures of Signals and Systems
Microelectronics
Power Systems and Power Electronics

scholastic achievements

One of the two recipients (amongst all PhD candidates) of the prestigious **Lyles Teaching Fellowship, 2020** by the Lyles School of Civil Engineering, Purdue University

Won **People's Choice Award** in 3MT® (Three-Minute Thesis) Competition during the 6th ABE Graduate Industrial Research Symposium on March 25th, 2019. Topic – **I-LIVE: Image-LiDAR Interactive Visualization Environment**

Secured **First Position** in 3MT® (Three-Minute Thesis) Competition on Plant Phenomics and Related Studies organized by the Institute for Plant Sciences, Purdue University on:

- February 21st, 2019: **I-LIVE: Image-LiDAR Interactive Visualization Environment for High Throughput Phenotyping**
- July 31st, 2018: **Multi-sensor Mobile Mapping Systems: Calibration and Applications**

Acknowledged with **Best Presentation-cum-Internee** Award by Civil Engineering Department, IIT Kanpur for “Estimation of Evapotranspiration using Trained ANN Hydrologic Models”

Selected for **KVPY Scholarship**, 2011 by Dept. of Science and Technology, Govt. of India

extracurricular activities

Sports **Best Incoming Sportsperson**, 2011 from amongst more than 800 students of my batch.

Basketball

Member of Basketball Team, representing IIT Kanpur in Inter-IIT Sports Meet from 2011-16.

Gold Medals in Udghosh 2013 and MNIT Sports Meet, 2012 (Inter-College Tournaments).

Silver Medals in Kanpur District Sports Meet, 2014 and Udghosh 2014.

Bronze Medal in Inter-IIT Sports Meet 2012.

Athletics

Gold Medals in Shotput, Discus Throw, 100 m, 200 m and 400 m, 4x100 m Relay, Long Jump in Josh 2011 (Intra-College Tournament).

Others Solving Rubik's Cubes (2x2x2, 3x3x3, 4x4x4, 5x5x5, Mirror Cube, Pyraminx, Megaminx).

Guinness Book of World Records Attempt: Succeeded as a team in solving 1884 Rubik's Cubes simultaneously.

volunteer work

Counselling Service, IIT Kanpur

2013–14

Senior Academic Mentor: Provided direct academic help to batchmates and juniors.

Student Guide: Helped 6 fresher students adapt to an entirely new environment at IIT Kanpur.

Coordinator, SOCE (Society of Civil Engineers), IIT Kanpur

2013–14

Organized events, informative sessions and workshops for the welfare of students of Civil Engineering.

Executive, TEDx, IIT Kanpur

2013

Served as a link between institute and pioneers of various fields by putting forth purpose of the event and persuading them to deliver insightful talks.