Apoorve Singhal

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Education

B.Tech. and M.Tech (Dual Degree) in Computer Science   **Graduating 2022**
Indian Institute of Technology Kharagpur, West Bengal, India   *GPA 9.20/10 (after 7 semesters)*

Senior Secondary School Examination   **2016**
Jayshree Periwal High School, Jaipur, Rajasthan, India   *GPA 9.38/10*

Interests

2D/3D Computer Vision, Interpretability, Explainability, Multimodality, Deep Learning, Machine Learning

Publications

- **Singhal A.**, Singh. C, Shah. N, Khandelwal. Y, "Model-agnostic information biasing for Visual Question Answering", *ACM CODS-COMAD 2021*
- **Singhal A.** et al., "Real-time Lane Detection, Fitting and Navigation for Unstructured Environments", *International conference on Image, Video Processing and Artificial Intelligence, 2019*. **Oral presentation**
- **Singhal A.** et al., "A Prototype of an Intelligent Ground Vehicle for constrained environment: Design and Development", *International Conference on Control and Robot Technology, 2019*

Research Experience

Self-supervised 3D human reconstruction   **Wadhwani Institute of AI, India**
Internship, Advisor: Dr. Rahul Panicker   *May 2020 - July 2020*

- 3D human reconstruction is a problem with very diverse and useful applications. The collection of labelled 3D data is an expensive and time-consuming process requiring special hardware while 2D video data is available in abundance
- Developed a novel self-supervised technique for improving 3D human reconstruction by using unlabelled video data
- Exploited disentangled nature of human pose and appearance by formulating a self-supervised reconstruction loss
- Gained 5% improvement in RMSE in 2D keypoint detection over supervised model Human Mesh Recovery (HMR)

Student-teacher attention transfer in Visual Question Answering (VQA)   **IIT Kharagpur, India**
Project, Advisor: Prof. Abir Das   *January 2020 - Present*

- VQA is the task of answering natural language questions about images. Attention mechanisms improve performance but are not well-understood. We investigate past works and develop a model-agnostic approach to improve attentions.
- Proposed a student-teacher attention transfer framework for improving any existing attention-based VQA architecture
- Devised a novel angle-based gradient update method for simultaneous optimisation of multiple objective functions
- Achieved improvement of +0.95% and +0.57% on benchmarking models MFB and BAN, using same amount of data

Data-efficient sneeze audio classification   **IoTBox Systems, Israel**
Research and Deployment Internship   *January 2020 - March 2020*

- Abnormal sneeze sound of a person can be used for prognosis of respiratory diseases. Experts with domain knowledge are required for data labelling. Due to the expensive and non-scalable approach, labelled data is not readily available
- Architected a hierarchial sneeze classification model for several sneeze classes using less data (total ~2500 audio files)
- Investigated image-based models and compared performance of MFCC, Log mel spectrogram, chroma, etc. features
- Redesigned a deep VGGish network to enable transfer learning and achieved an accuracy of 83% (sneeze/non-sneeze), 80% (real/fake) and 60% (soft/loud/stifled/dramatic) by combining transfer learning with various data augmentations
- Deployed the model on a user-friendly website developed using Flask and Streamlit hosted on Azure Virtual Machine

Research Products

Low-cost social distancing monitoring device   *March 2020 - May 2020*

- Developed a portable low-cost device (total cost $< \$60$) to monitor and encourage social distancing in crowded areas
- Implemented ~4 fps person detection on a custom-trained Mobilenet SSD on a Raspberry Pi with a rotating camera
- Achieved an error of 7 cms/metre for person-to-person ground distance by using a calibrated homographic projection
- Endorsed by Minister of Education and covered by all major media outlets like NDTV, Tribune, Hindustan Times etc.

Speed Breaker detection *July 2018 – September 2018*
- Developed a speed breaker detection system for autonomous vehicles for detection from a distance of 15 metres ahead
- Curated a dataset of 20,000 speed breaker images using various augmentations such as vertical flips, motion blur etc.
- Implemented a lightweight CNN model for speed breaker detection at ~30 fps on Intel i7 processor; test accuracy 92%

Face recognition based attendance system *September 2019 – November 2019*
- Developed a face recognition attendance system with facilities to expand into leave and payroll management systems
- Created a face recognition model based on MTCNN and adjusted it for robustness on Indian faces through fine-tuning
- Sped up the pipeline by ~60% by using k-nearest neighbour search in feature space instead of classification layers
- Deployed a web application to view real-time analytics about attendance and to add/remove/modify users remotely

Driver alertness detection *January 2019 – February 2019*
- Developed a system to detect the driver's alertness level based on various parameters like blinking rate and yawning
- Integrated the system with an electric vehicle to take safety actions like halting to the side if the driver is not attentive

GPS and Camera Mapping *July 2019 – September 2019*
- Developed a low-cost mapping tool for efficient storage and retrieval of lane markings when detection is not feasible
- Predicted the GPS coordinates of a ground point in an image using a camera, filtered GPS, IMU and odometry data

Competitions

Intelligent Ground Vehicle Competition (IGVC) 2019 **Oakland University, Michigan, USA**
Team leader, Advisor: Dr. Debashish Chakravarty *February 2019 - June 2019*
- Built a three-wheel differential drive bot capable of following lanes and avoiding obstacles to reach a set of GPS targets
- Secured the 1st position in the qualification round and the 2nd position in the finals of the AutoNav challenge, 2019
- Led the software team to design an algorithm to identify obstacles and lane markings using a camera and 2D LiDAR

Hardware Modelling 2019 **IIT Kharagpur, India**
Software Team Head *March 2019 - April 2019*
- Designed and implemented the dirt detection and solid avoidance algorithm for an autonomous river cleaning robot
- Deployed the navigation algorithm as a ROS node on a Raspberry Pi 4; secured the 2nd position amongst 20 teams
- Authored the software section of the final project report with details about software, hardware and associated costs

Awards and Achievements

- Ranked 1095 (99.9 percentile) from over a million candidates in the Joint Entrance Examination (Main) 2017
- Stood 310 (99.87 percentile) from 250,000 candidates in the Joint Entrance Examination (Advanced) 2017
- Awarded the Student Par Excellence 2018-19 Award for outstanding academic performance in the first year
- Offered a position in the Undergraduate Achiever's Directory 2019 edition for diverse research contributions
- Awarded the 1st position in Pixelation 2018 for developing the fastest autonomous maze traversing robot
- Won Best Fresher in Fortress 2017, a national competition to build an autonomous pattern-matching agent
- Secured 1st position in RoboSoccer 2017, an intra-collegiate competition to build a soccer playing robot

Mentorship and Leadership

Institute Mentor and Hostel Mentor *July 2019 - Present*
- Responsible for guiding 6 freshmen, focusing on their academic and holistic development and providing counsel
- Selected as a hostel mentor for guiding 5 hostel students focusing on their academic performance and mental health

Vice-captain, Hostel Football Team *January 2020 - March 2020*
- Vice-captain of the silver-winning football team from over 20 teams in the yearly intra-collegiate football competition
- Organised daily 3-hour running and practice sessions for 25 teammates for 2 months; coordinated friendly matches

IEEE Winter Workshop on Image Processing and Computer Vision *December 2019*
- Taught a 7 day hands-on course on "Image Processing and the basics of Computer Vision" to 200+ 1st year students
- Formulated challening problem statements for end-workshop evaluation and mentored students on their projects

Induction Programme *October 2019*
- Delivered a talk on the history, interesting tasks and future work in Computer Vision at Induction Programme 2019
- Conducted an interactive session to introduce the concepts of artificial intelligence and neural networks to freshmen