**Dinesh Manoshi – Distinguished Speaker**

* Dinesh Manocha
  + University of Maryland at College Park
  + Computer Science
  + Electrical & Computer Engineering
* Robot Navigation in the Wild
  + Goals
    - Autonomous robots are the future
      * Rich people are saying so
    - Perform smooth and safe path computation through cluttered environments
* Applications
  + Waiters in restaurants
  + Home robots
  + Security and surveillance robots
  + Food delivery robots
  + Planetary rovers
  + Inspection
* Not fully autonomous
  + Currently someone monitoring it
* Challenges
  + Capabilities to travel freely in any static or dynamic environment
  + Smooth and safe path computation
  + Social navigation for human-robot interaction
* State-of-the-art
  + Environments configured to be “robot friendly”
  + Few or no humans in proximity
  + Sensors and lighting conditions for improved perceptions
* Robot in the house is a difficult problem
  + Hardest location is bathroom
* Cannot work in crowded environments
  + Extremely challenging
  + Many corner cases
    - Rain
    - What if vision does not work
* Someone remoting watching the robot
  + Waymo
  + Robot in home
* Robot Processing Pipeline
  + Perception (sensing) => Planning (Plan) => Control/Action (Move) and loop
  + Discuss indoor and outdoor challenges
    - Indoor
      * Flat
      * Dense with obstacles
    - Outdoors
      * Rough terrain
      * Vegetation
  + Development of Motion Planners
    - 50 years
    - Classical Path and Motion Planning
    - Learning-based Planning
  + Edge cases cause the biggest problems
  + Based on data
* Combine new Perception and Planning algorithms to solve navigation challenges
* General algorithms to handle challenges using limited sensing and edge computing on the robot
* Work so far
  + Indoor Scenes
    - Problems
      * Biggest problem are crowds
      * Humans are the most unpredictable
      * Law stuff when robot hits someone
    - What was done
      * Crowd simulator
      * 70% consist of groups
    - Insight
      * Developed deep reinforcement methods
        + Pedestrian motion prediction
        + Network architecture
        + Reward function
        + Complex training environments
      * Look at velocity of humans and predict their locations
      * Classify pedestrians as potentially freezing and non-freezing
      * Construct potential freezing zone
      * Compute deviation angle for robot’s current angle
    - Metrics
      * freezing rate
      * pedestrian friendliness
    - Results
      * Worked in crowd
    - Used RL with geometric learning
    - Group People
      * Estimate group cohesion
      * Navigation
    - Handle glass and shiny objects
      * Use lidar (expensive and not always reliable)
      * Uses multi-level intensity maps
      * Use realtime navigation and mapping
      * Does not use deep learning
    - Navigation on edge hardware
      * Enhanced MPC-based Planner
      * Compute state cost, collision probability, and associated results
      * Low power solution implemented on Amazon astro
      * Did not have hardware
  + Outdoor Scenes
    - Challenges
      * Surface properties
      * Unstructured vegetation
        + Collisions
        + Freezing
        + Entrapment
    - Insights
      * Can we learn how to navigate by correlating a robot’s observations with its surface interaction?
      * Can we identify vegetation by comparing them with references?
    - TerraPN
      * Inputs: RGB and velocities
      * Preprocessing
      * Surface Cost Prediction
      * Navigation
    - Uses a cost map to determine which terrain is robot friendly or not
    - Vegetation Classification: VERN
      * Tall grass
      * Bushes/shrubs
      * Trees
    - Made vegetation classification architecture
      * Determine which vegetation to go through
    - Using proprioceptive estimation => feel of touch by analyzing vibrations
    - Worked with army
    - Method’s benefits
      * Add new contexts and behaviors easily
      * Zero-shot detection and behaviors
    - Recently working on behavior rule guided autonomy using VLMs
  + Autonomous Excavator
    - Help construction vehicles navigate for construction
    - Used a lot of computer vision algorithms

The talk is *Robot Navigation in Complex Indoor and Outdoor Environment* by Dinesh Manocha from UMD. Manocha’s talk describes challenges that affect autonomous robots today which are that robots cannot travel freely in a static or dynamic environment, computing a smooth and safe trajectory is difficult to do, and social navigation for environments with lots of humans are extremely difficult. Specifically, humans are the most dangerous obstacles because of their unpredictability. Additionally, Manocha divides two different types of terrains: indoor and outdoor. Indoor environment is generally flat but typically has a lot of people while outdoor terrain is rough and has vegetation. Current state-of-the-art requires someone to remotely monitor the robot during its operation and take control when something goes awry. Manocha describes his research regarding his work for both indoor and outdoor environments. For the indoor environment, Manocha and his team created a crowd simulator in which 70% consisted of groups. Then, his team created a deep reinforcement learning (rl) algorithm with geometric learning that looks at the velocity of humans and predicts their locations. Their deep rl method uses predictions to create “freeze” zones which are essentially areas that the robot should avoid. For the outside environment, Manocha and his team developed an algorithms that uses a vegetation classification called VERN which is used for the robot to determine which vegetation it can move through. Another approach that was considered was using proprioceptive estimation where the robot feels its environment to determine whether it can run on it or not. Finally, Manocha and team are working on an autonomous excavator which uses computer vision algorithms for construction purposes. There are a couple of key ideas and highlights that I learned, and think is important. It was interesting to learn that if a robot were to navigate through someone’s house, the most difficult room would be the bathroom due to all the mirrors and shiny surfaces. This thought never occurred to me but after thinking about it, it made sense. Another interesting highlight was distinguishing between indoor and outdoor environments. I have never thought of it in that way.