Many mobile robot applications focus of navigation of robots in unknown, albeit regular, smooth, and engineered, terrains. The deployment of autonomous mobile robots into natural terrains presents additional challenges. Take the Curiosity Mars rover for example. Martian terrain is not smooth and flat like a warehouse floor, but curved, sloped and rough. Ignoring these environmental characteristics can cause navigational failure, such as the robot becoming stuck. Seraji and Howard sought to implement human like navigation strategies through a fuzzy logic control scheme in mobile robots to enable them to navigate challenging terrain.

Three fuzzy characteristics of the environment were taken into consideration to navigate the robot to its end-goal: texture, slope, and regional separation size. To determine texture, stereoscopic computer vision was used estimate a representative size and concentration of nearby rocks. The size fuzzy sets were Small and Large, and the concentration sets were Few and Many. These were the predicates to several fuzzy rules which determined the membership values of Smooth, Rough, and Rocky fuzzy texture sets. A neural network was trained to estimate the slope of the terrain based on the stereovision, to provide a crisp input to Flat, Sloped, and Steep fuzzy slope sets. Regional separation size was a measure employed to recognize when two otherwise homogeneous regions were separated by a cliff or ditch. Fuzzy inference rules were used to combine these three characteristics’ fuzzy sets into membership values for traversability index sets, either Low, Medium, or High.

Like many mobile robot navigation schemes, the output variables were the drive speed and rotation rate. Drive speed had Stop, Slow and Fast sets. Rotation rate had Large-Neg, Med-Neg, Small-Neg, Zero, and corresponding positive sets. Traversability index memberships were determined for each of seven radially arranged sectors in front of the robot. These traversability fuzzy sets were combined in another rule system to determine the medium-range terrain traversal behavior’s desired steering direction. The traversability in front of the robot was sufficient to determine the desired speed.

Obstacle avoidance behavior was implemented for short-range navigation and global goal seeking behavior was used for long-range goal seeking behavior. These two behaviors rely on distance to obstacle, and end-goal heading measurements. They are treated extensively in literature. Of the three behaviors, the one with the largest weighting factor was exclusively used for the current output. The weighting factors were determined by additional fuzzy rules reflecting the magnitudes of the inputs to the fuzzy sets. The robot was fairly successful at navigating a variety of natural terrains which included rocks, large slopes, and gaps.

This paper is an interesting example of more advanced navigation functionality being implemented with fuzzy logic. While many works use simple range sensors to detect and avoid obstacles, this robot uses stereovision. The reader is referred to the appropriate works for details on how rock sizes and concentrations, and terrain slope are gauged with vision. This leaves the reader to consider only the fuzzy aspects of their implementation, abstracting away the complicated details of computer vision. This makes for an accessible paper; technical matters are almost exclusively ones covered under fuzzy logic.