Sensors

Objective: Augment stereo range & uncertaininity image with fast, local range sensors.

- **Contact sensing of collision by bumper device around the foot perimeter**
- **Foot contact sensing by compliant pad with embedded sensors or by piezoelectric pads**
- **Light striping**
- **Lookdown VLSI range image sensor**
- **Infrared/Laser range elements on feet**

Control

Objective: Incorporate behavior into control loops to reduce complexity and increase response.

- **Fast PID not needed due to slow overall motion and low trajectory accuracy requirements**
- **Fuzzy mapping gives ability to integrate kinematic, dynamic and actuator models without overhead.**
- **Fuzzy logic controllers can seamlessly integrate exception handling into the control loop and provide fast response without using interrupts.**

Model: Still being worked on including an adaptive scheme to fine tune it on the fly

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Planning Informaton Requested

Objective: Use planning information to make educated guesses to intent of motion.

- **Direction of motion, step size, final pose**
- **Detailed final pose if in deliberative mode**
- **Constraints like max acceleration on slopes**
- **Intended local direction (pure pursuit direction)**
- **Information on niceness of neighborhood (5m)**
- **Constraints on viable directions if applicable**

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Stereo Stratergy

Objective: Streamline stereo processing to maximize resolutions in the given time. Utilize ability to change resolutions on the fly.

- **Resolution suggested = half foot size x 10 cm (or a practicable).**
- **Take snapshot at the end of body motion as legs go down. Least vibrations, pose almost ideal.**
- **Take snapshot during middle of walking cycle before deceleration. More processing time, non-ideal pose, vibrations (long. and lateral). Design mast for vibrations? How do vibrations affect stereo?**
- **Pan and tilt may be required if second option is used.**

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Search Stratergy

Objective: Evolve priorities to enable planning and search to integrate walking behavior.

- **Leg motions < Body rotations < Body acceleration < Vertical motions < Slope traverse < Robot eating canyon.TB quantified by power.**
- **Classify terrain in terms of traversibility and hazard. Use these measures in A-Star search.**
- **Traversibility includes obstacles, slopes, forgiveness to errors.**

EX1 :A smooth path 3m wide with drops on either side is BAD. However an identical path with steep sides is very good.

EX2: A 20m detour is preferable to a 10m path with a 1m climb and descent.

Walking Scheme

- Use 2.5 D uncerainity grid. Each cell consists of z value and certainity/evidence. Grid size = 1/8 of foot diameter
- Pick the feet upto the 1.2 x highest obstacle in stereo map and move body
- Constraint : Keep feet 20 cm away from known obstacles
- Constraint : Ensure stability margins by periodic checks
- Constraint : Correct body pose to within 2 deg every step
- Utilize behavior to get near optimal time performance

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Walking Scheme

Objective: To move as close to the goal as possible using (robust) reactive behavior.

- **Guided by cost function f(energy, error).**

$$Energy = f_1(t, Power)\ ;Power = Max \Rightarrow Cost = G(t, error) + PoseCost$$

$$G = \sqrt{\left(\frac{t}{t_n}\right)^2 + \left(\frac{e}{R}\right)^2}\ ;t_n = nominal;\ \frac{e}{R} = \left(\frac{error}{Step}\right)$$

- **Cluttered field is defined by crossover time between walking and deliberative walking**

$$Te = t_{OLD} \times 0.9 + t \times 0.1$$