Haptic Robots

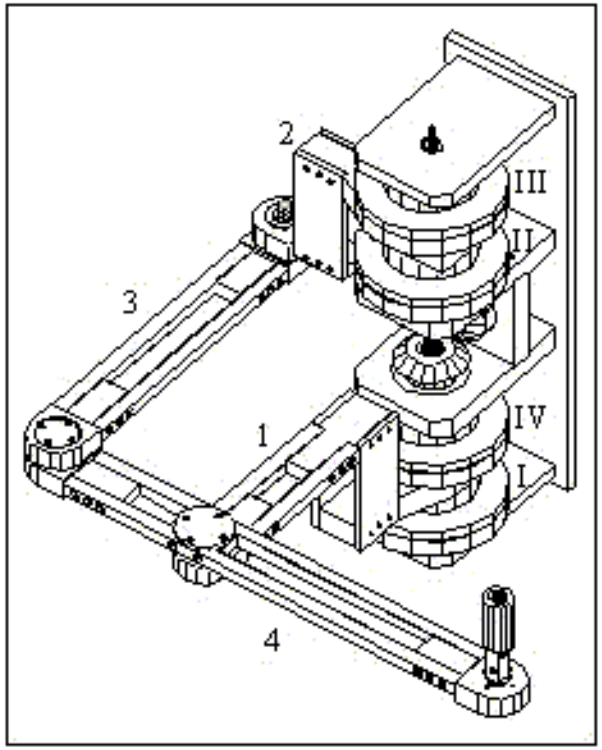
- Haptic Robots can be thought of as a super joystick that feeds back "touch" information to the user.

- Uses
  - Teleoperation of remote equipment
  - Virtual Environment
  - Assisted movement

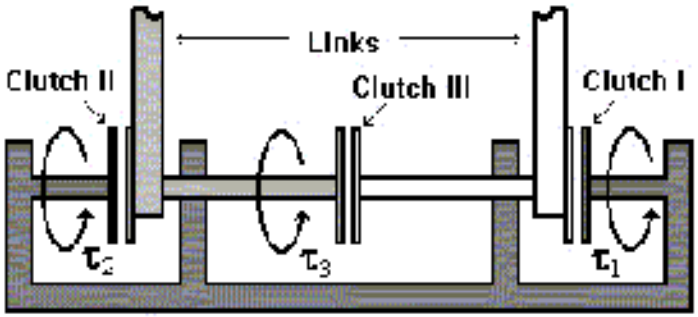
- Passive vs. Active
  - Can not add energy to the system, but can only dissipate, redirect, or store energy supplied by the user.
  - Intrinsically safer in the case of machine malfunction

Birth of PTER
(Passive Trajectory Enhancing Robot)

- Father -- Robert Andrew Charles - 1994
- 2 DOF Planar arm
  - 5 Bar linkage
  - Utilizes electromagnetic clutches / brakes to couple links & effectively decrease the DOF
- Based on its brother HURBIRT
  (Human Robot Bilateral Research Tool)
  - Kinematically Identical
  - HURBIRT is an active Haptic Robot
    (Receives energy via electric motors)

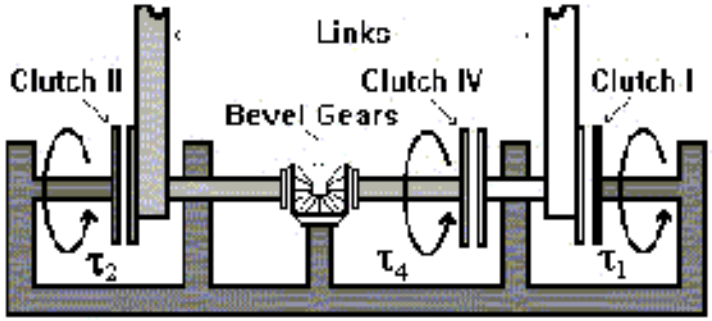


Clutch Configuration



Direct Coupling of Link 1 and Link 2

Inverse Coupling of Link 1 and Link 2



PTER Begins to Learn

- **PTER develops intelligence** (Hurley Davis - 1996)
  - PTER is given a brain
    - *486 - 50 mhz with Metrabyte D/A & A/D interface*
    - *Programming in C*
  - Rule - Based control algorithms using feedback from position and force sensors (tested for a circular path)

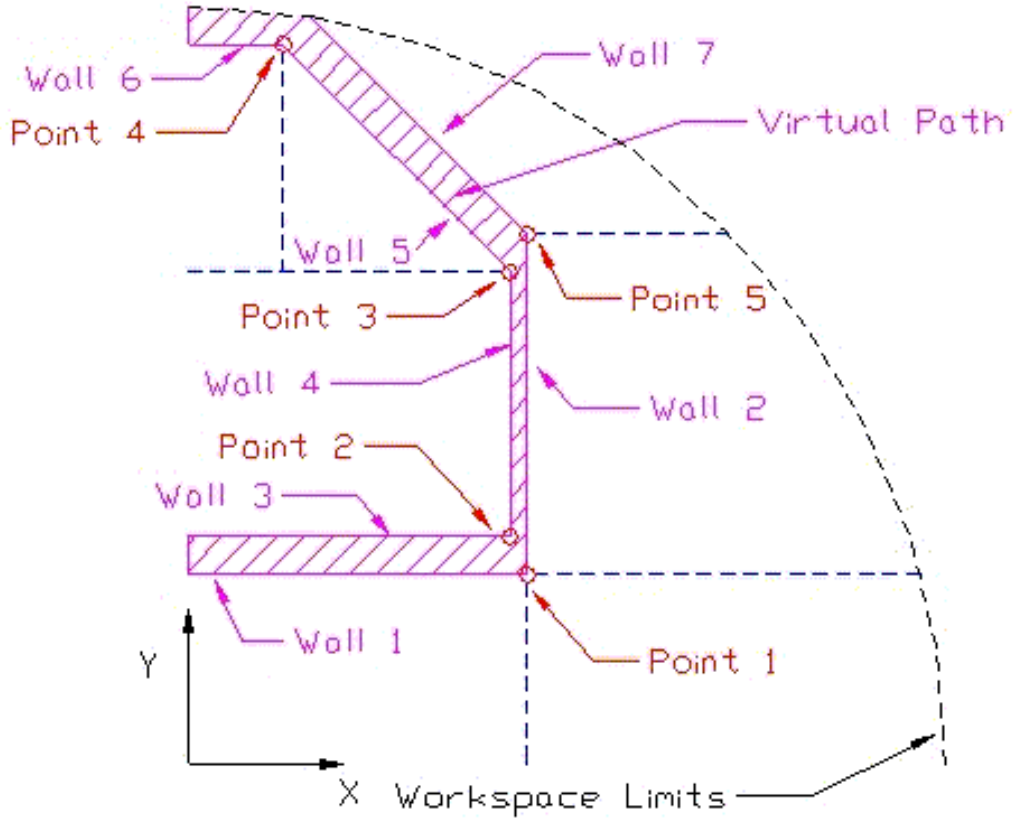
- **PTER goes to school** (Mario Gomes -- 1997)
  - Analysis of physical constraints
    - *Pure Time Delay & First Order Response of clutches*
    - *Recalibration of clutch torques*
  - Further developed control algorithms
    - *Simulation of a Horizontal virtual wall*
    - *Quantitative performance measures*
    - *Clutch Blending*
    - *Made more general to simulate any wall orientation (Lawrence Tognetti)*
      - *Extended to form a virtual corridor or hallway*
  - Compromise between smoothness and accuracy

Potential Future Plans

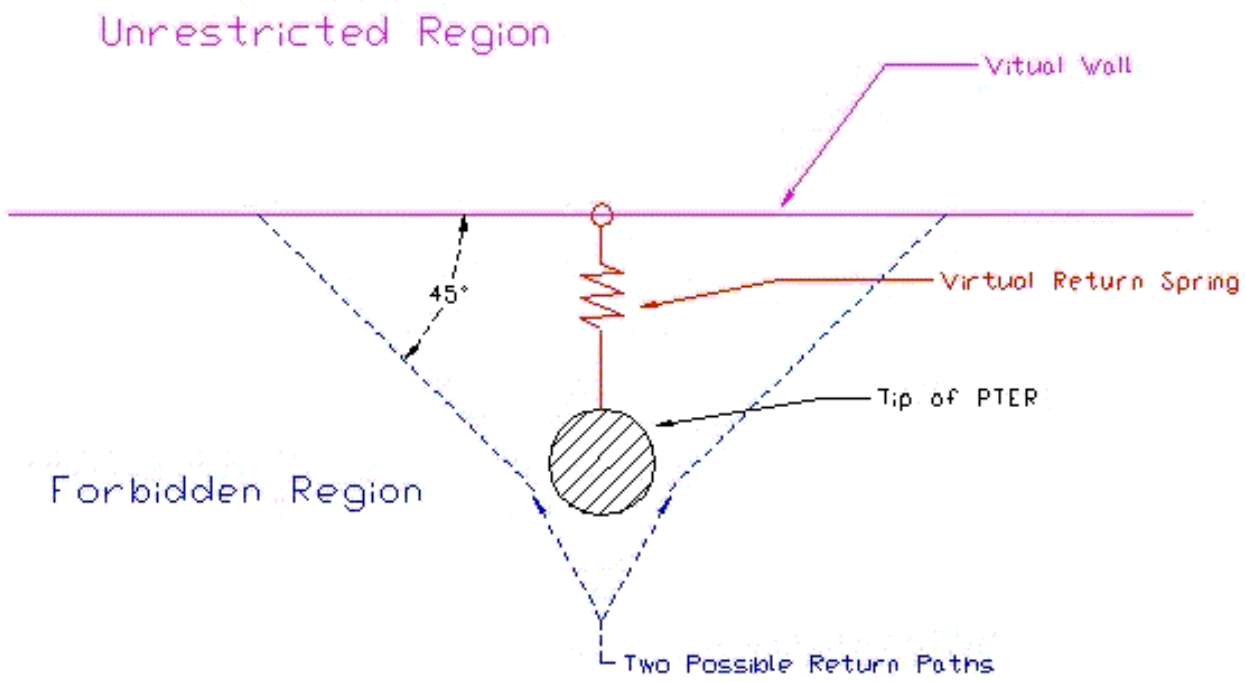
- **PTER gets a physical**
  - Assess clutch upgrades & potential mechanical / electrical modifications
    - *new clutches*
      - *electro magnetic particle, electro magnetic friction, custom friction, etc*
    - *gear reductions*
    - *improved sensors for feedback*
  - Model new (& old) clutches
  - Servo Control of clutches (Torque and Slippage control)
  - Reuse old algorithms with servo control
  - Develop new algorithms
  - Brain Transplant? (New Computer)

- **PTER'S Family**
  - Reunite PTER with his brother HURBIRT
    - *Teleoperation of HURBIRT*
  - PTER gets a little sister
    - *New smaller Haptic Robot*

Virtual Maze / Path for PTER



Return Path for Present Algorithm



Return Path for Modified Algorithm