

# Dynamically modified trajectory control of a 2 DOF manipulator

or

## How to teach a robot to dance

Eric J. Wilhelm

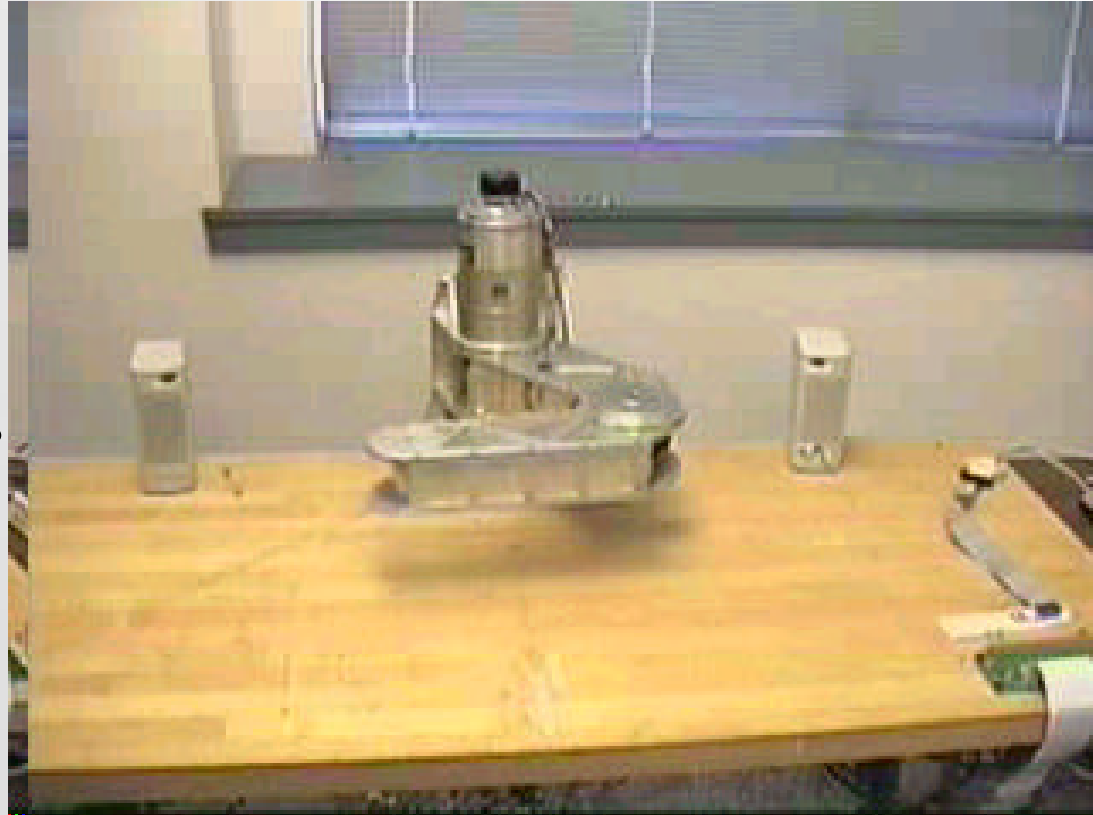
2.165

December 8, 1999

# Circular Position Control

## Outline

- Goals
- System design
- Experimental results
- Discussion
- Applications

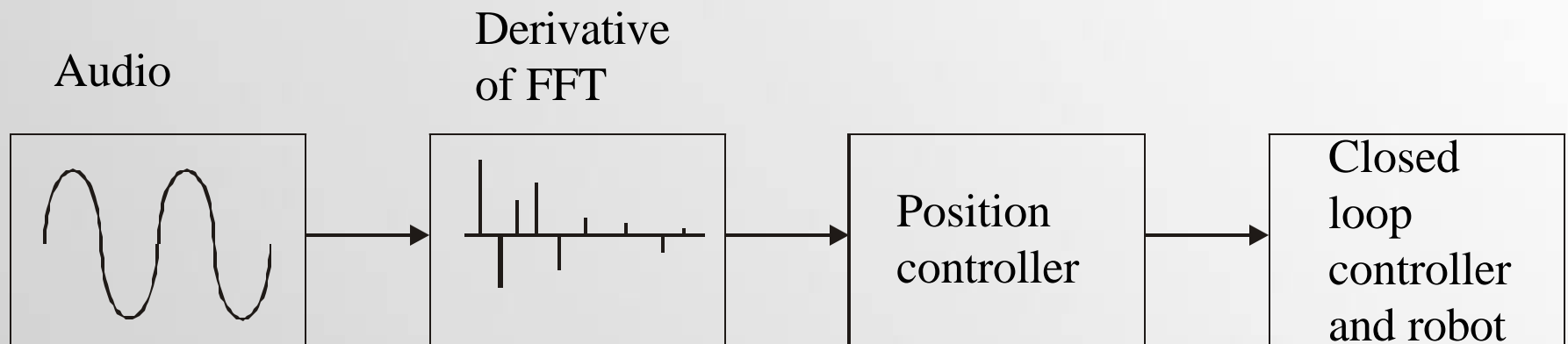


Dancing to “Dark + Long” by Underworld

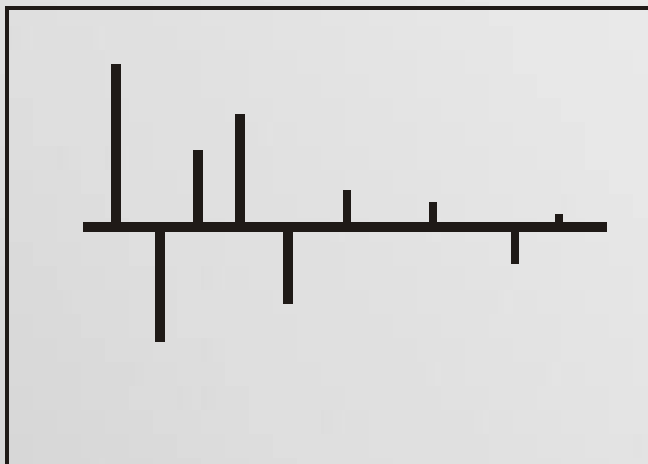
# Goals

- Create a system that would control the 2.165 laboratory robot based on music
- Design a controller which is responsive to changes in the music source
- Investigate trajectory tracking on a continuously changing path

# Block diagram of system



## Derivative FFT used to find changes in music



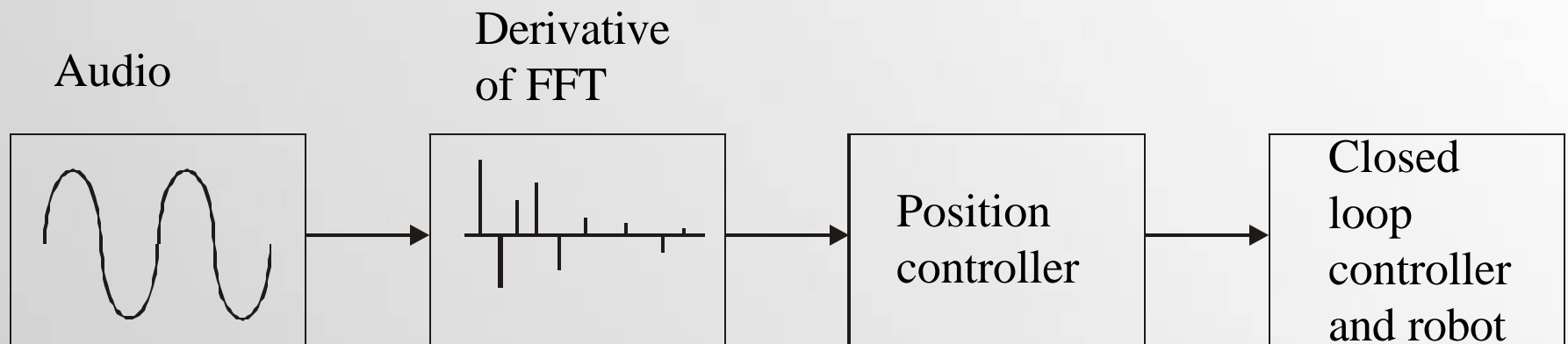
$$\frac{FFT[k+1] - FFT[k]}{t}$$

Three frequency ranges set

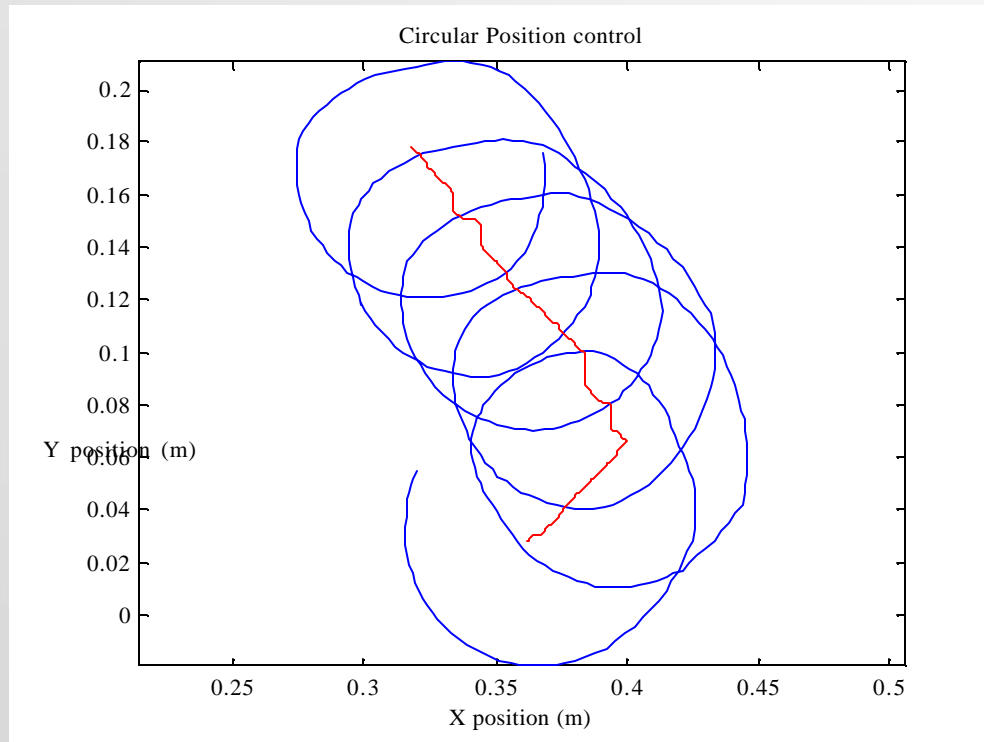
When the average value in a range exceeded a threshold a bit was changed on the parallel port

Data received on 2.165 robot computer through digital input

# Block diagram of system

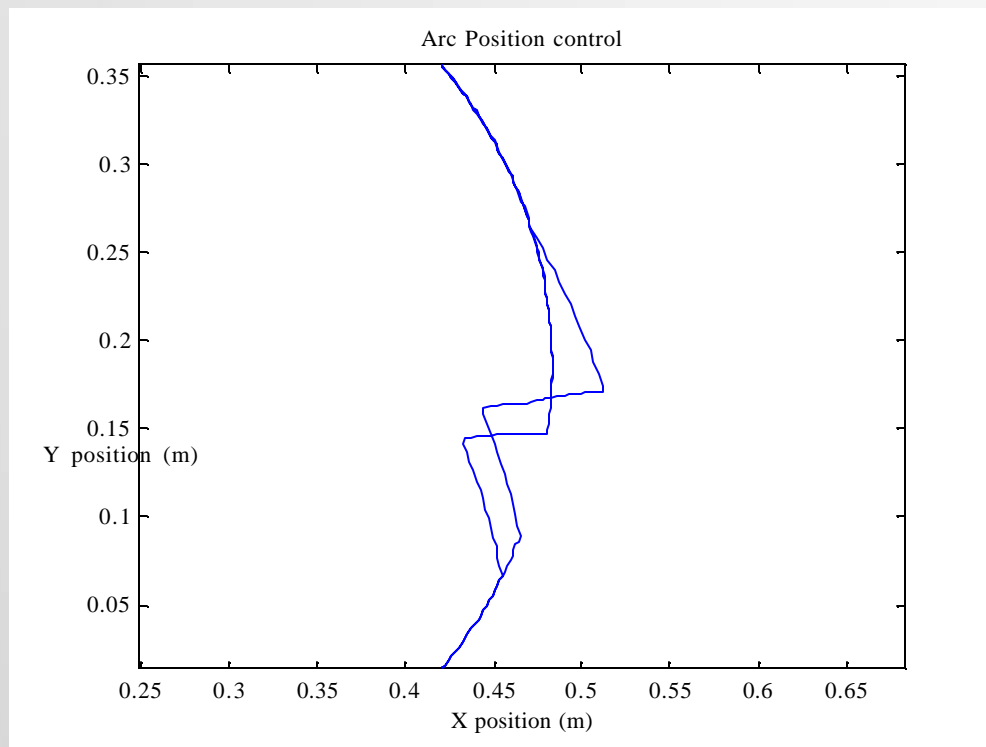


# Circular Position Controller



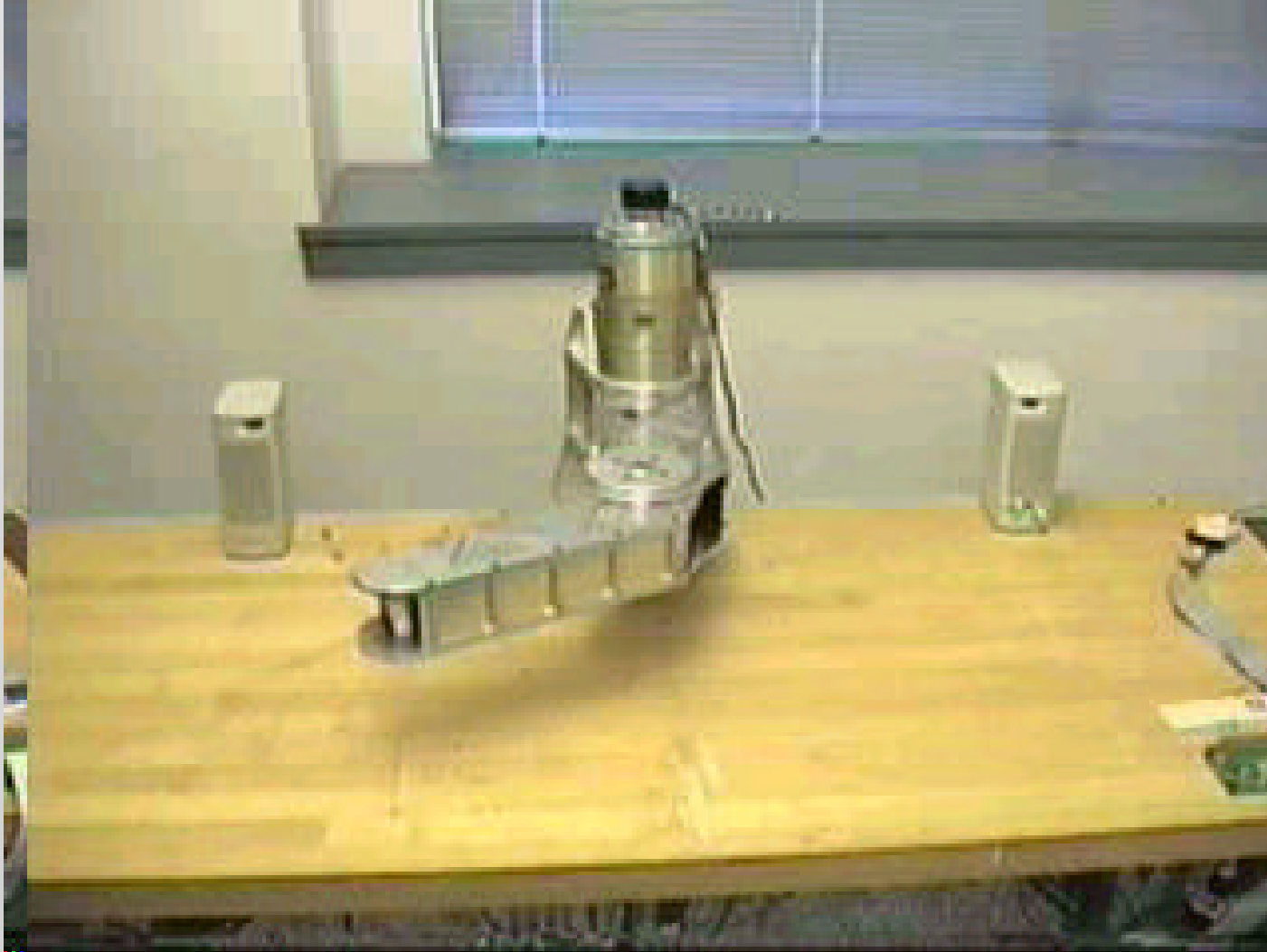
- Circular interval set by low frequency
- Center point position changed by mid and high frequencies

# Arc Position Controller



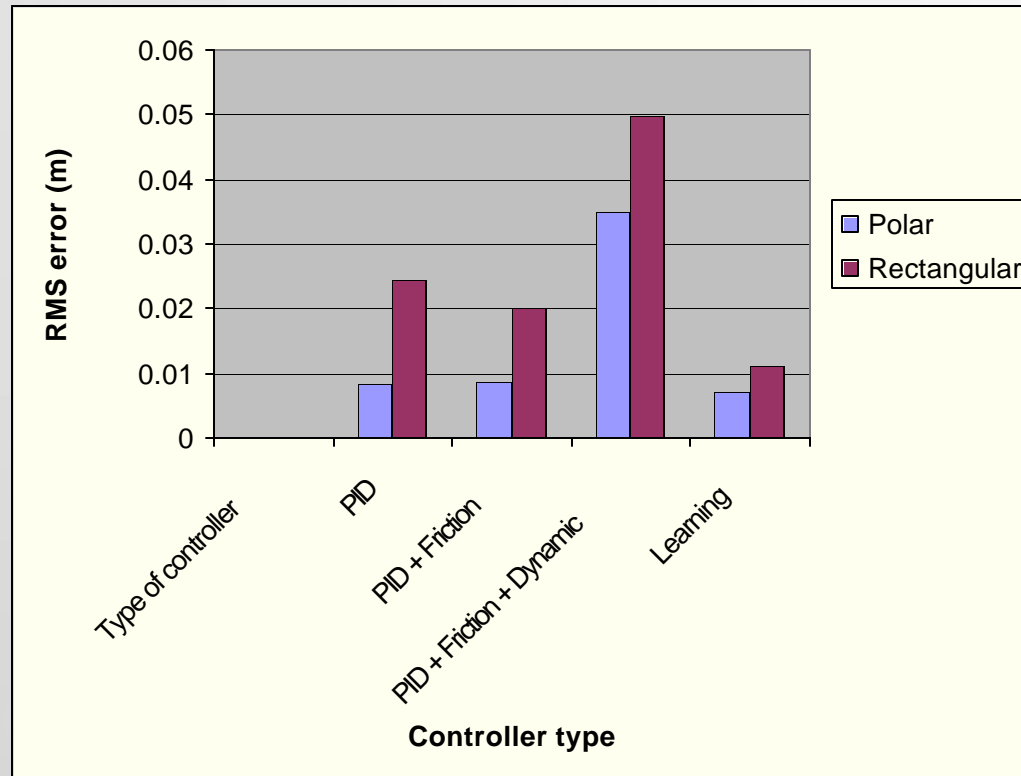
- Sweep interval set by low frequency
- Mid and high frequencies create “disturbances”

# Arc Position Control

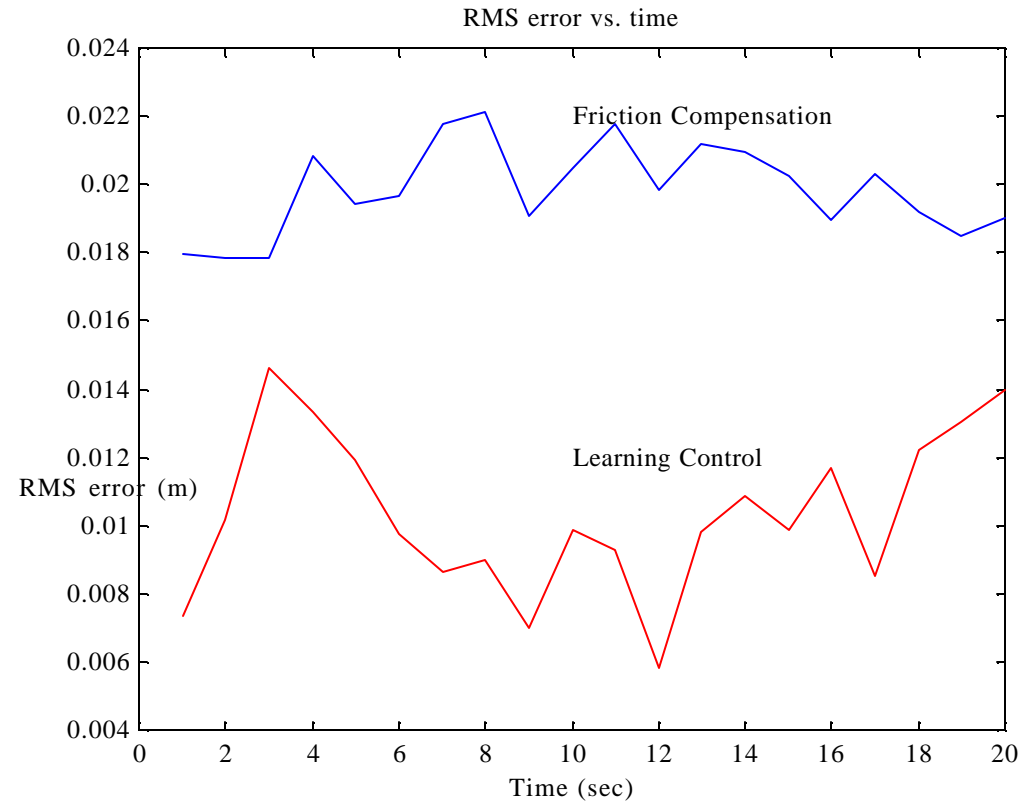


Dancing to “Take Five” by The Dave Brubeck Quartet

# Results



# Results



# Discussion

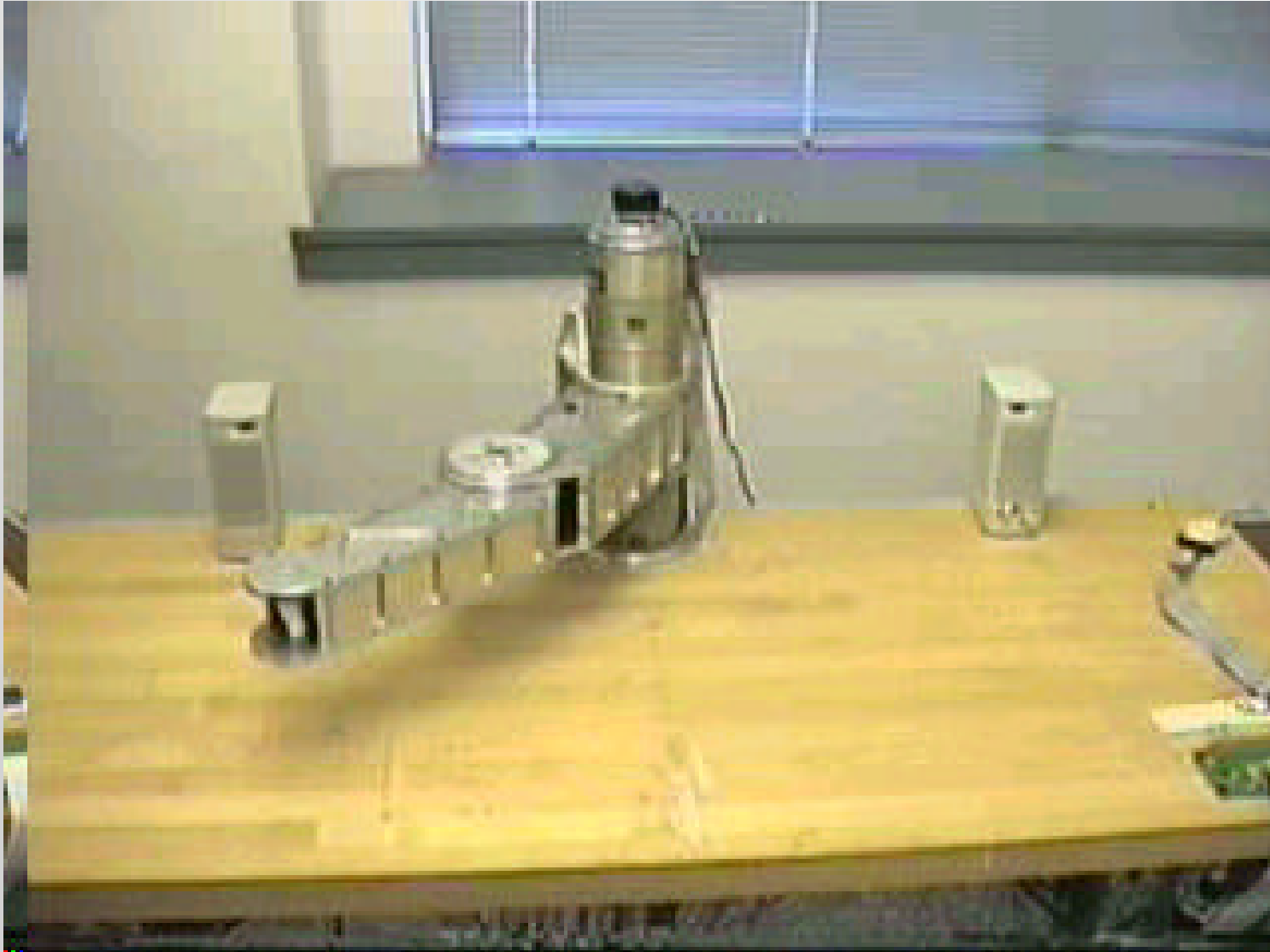
- Learning control has lowest tracking error despite moving center, however it did excite transmission dynamics
- Dynamic torque compensation has greatest tracking error due to errors in model parameters
- PID and PID+Friction compensation very similar

# Applications

- Derivative FFT control generation is useful for systems which model a natural response. Examples: Sony's Robot Dog and real-time control of laser and light shows
- Learning control with a moving "center" could be useful in applications where the local movement is known but the global position is not. Medical robotics; repetitive tasks such as sewing stitches



# Arc Position Control



Dancing to the end of "Dark + Long" by Underworld