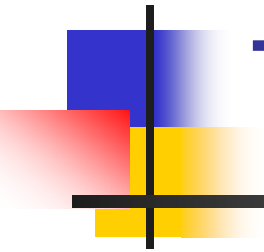
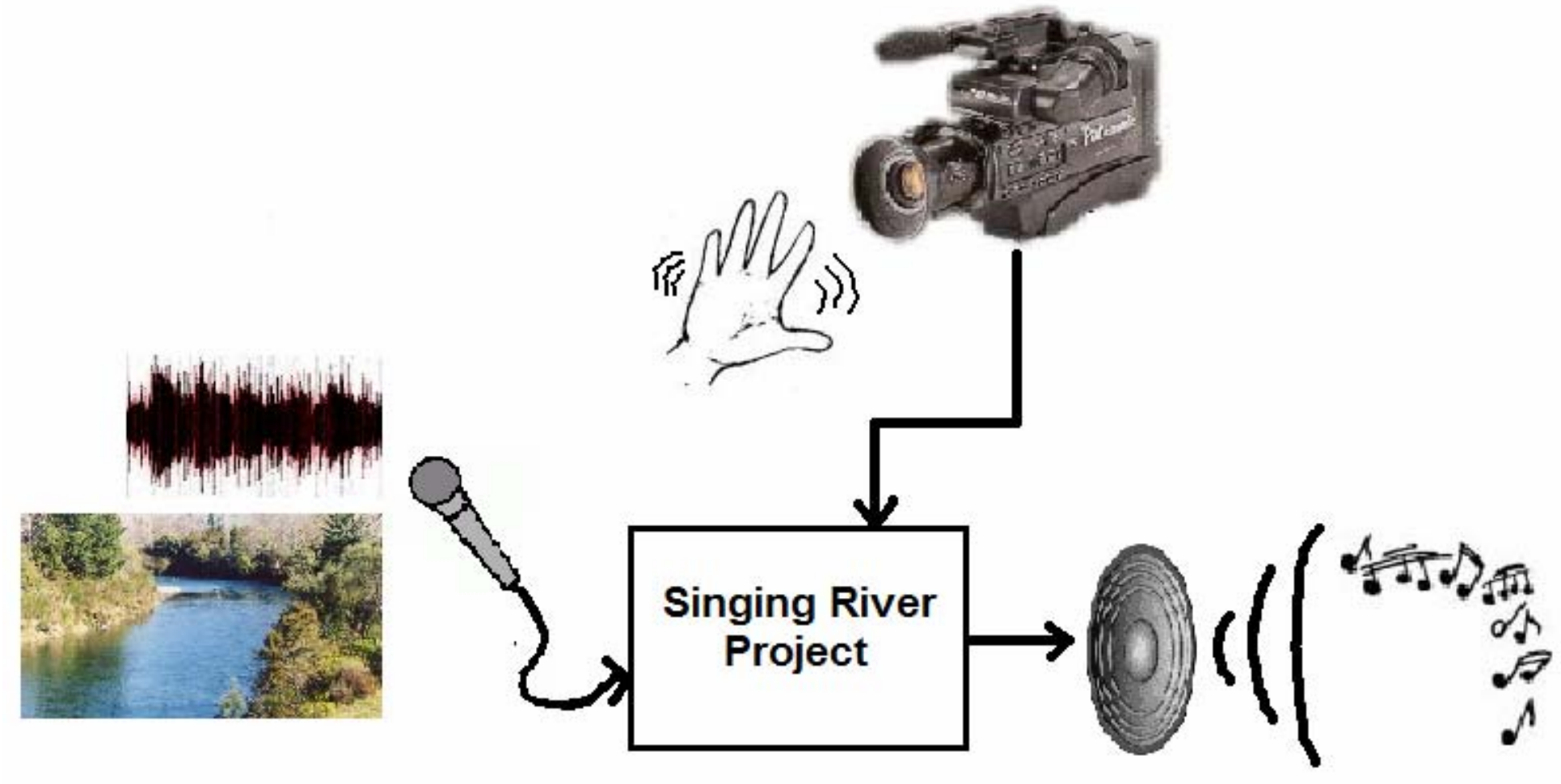
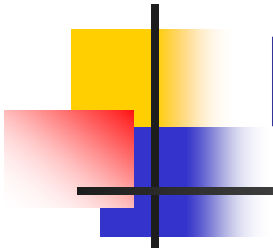


The Singing River Project

Kyle Gilpin
Kushan Surana
Andrew Wong

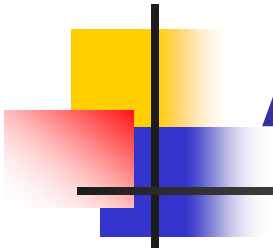
What is it?





Description

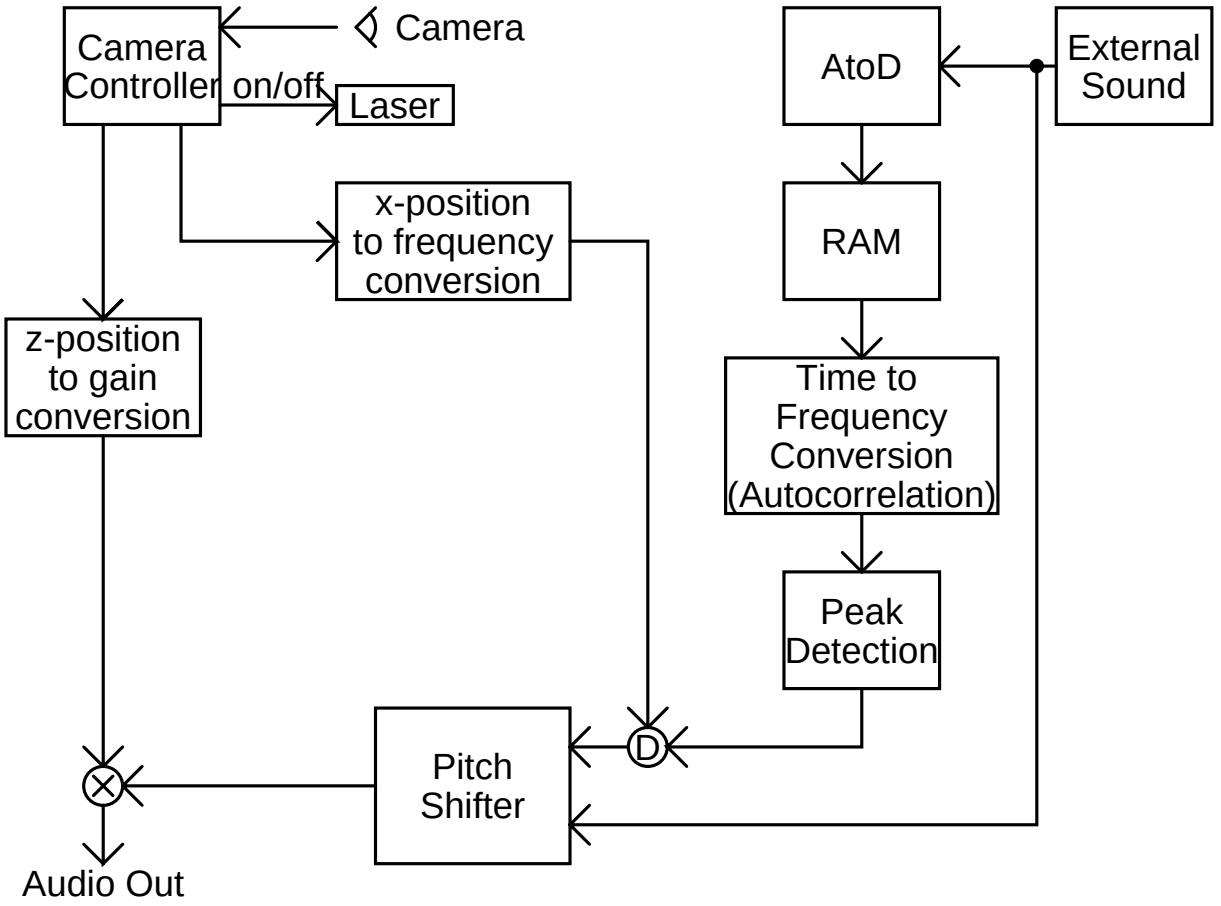
- Inputs: video image of hand w/ laser reflection, external sound source.
- Output: external sound source shifted in pitch and volume as specified by hand.

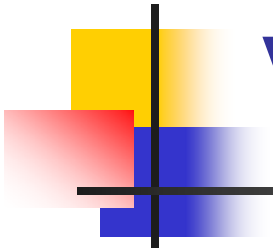


Applications

- New musical instrument, similar to the Theremin, but allows control over natural sounds (voice, river, 60Hz noise).
- Allows discovery of new timbres in music, sound synthesis.
- Allows multi-person control over one instrument: one person controls sound input timbre, second person controls frequency and volume.

Overall Block Diagram

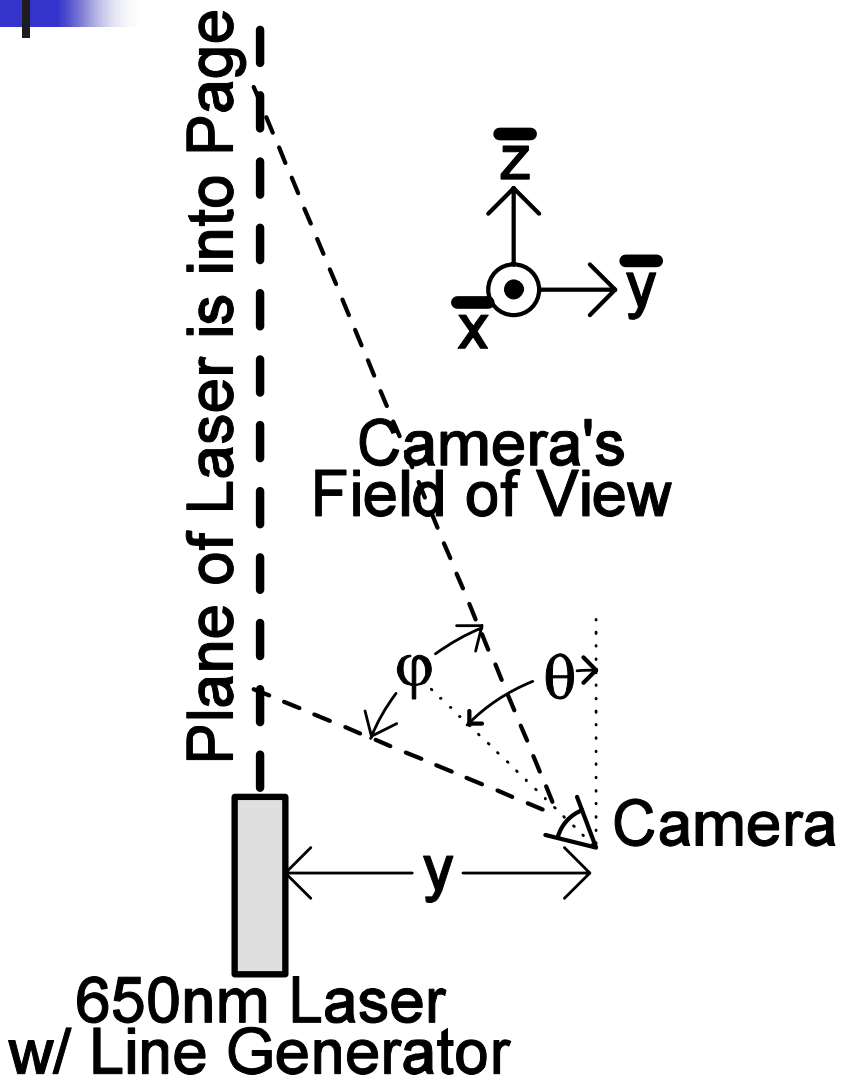




Vision Subsystem

- Detect the position of an object within a 2-dimensional field of view.
- Components:
  - laserline generator
  - optical bandpass filter
  - B/W CCD camera
- Very few environmental constraints for accurate detection

Physical Setup



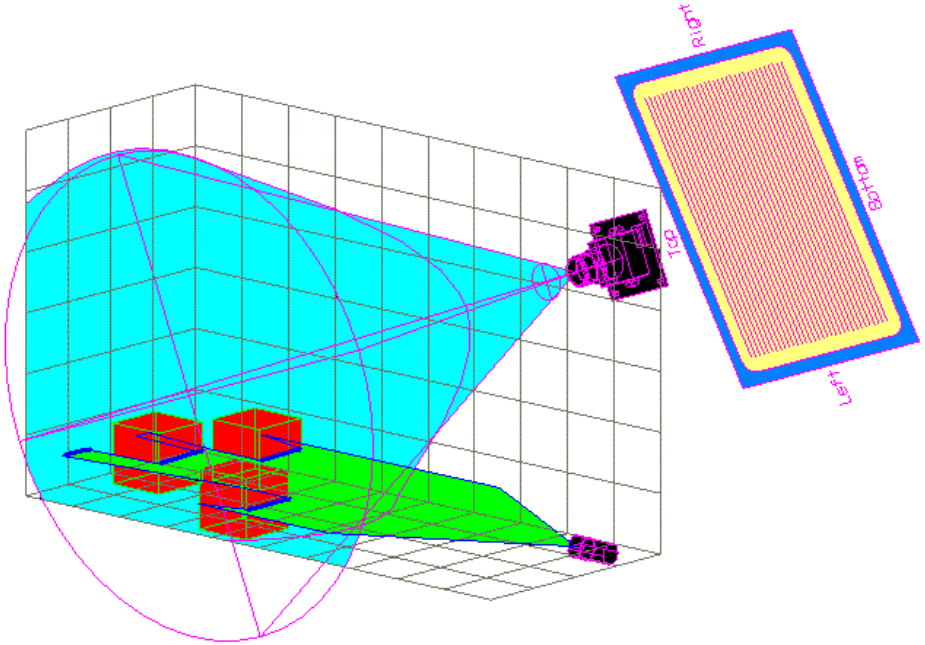
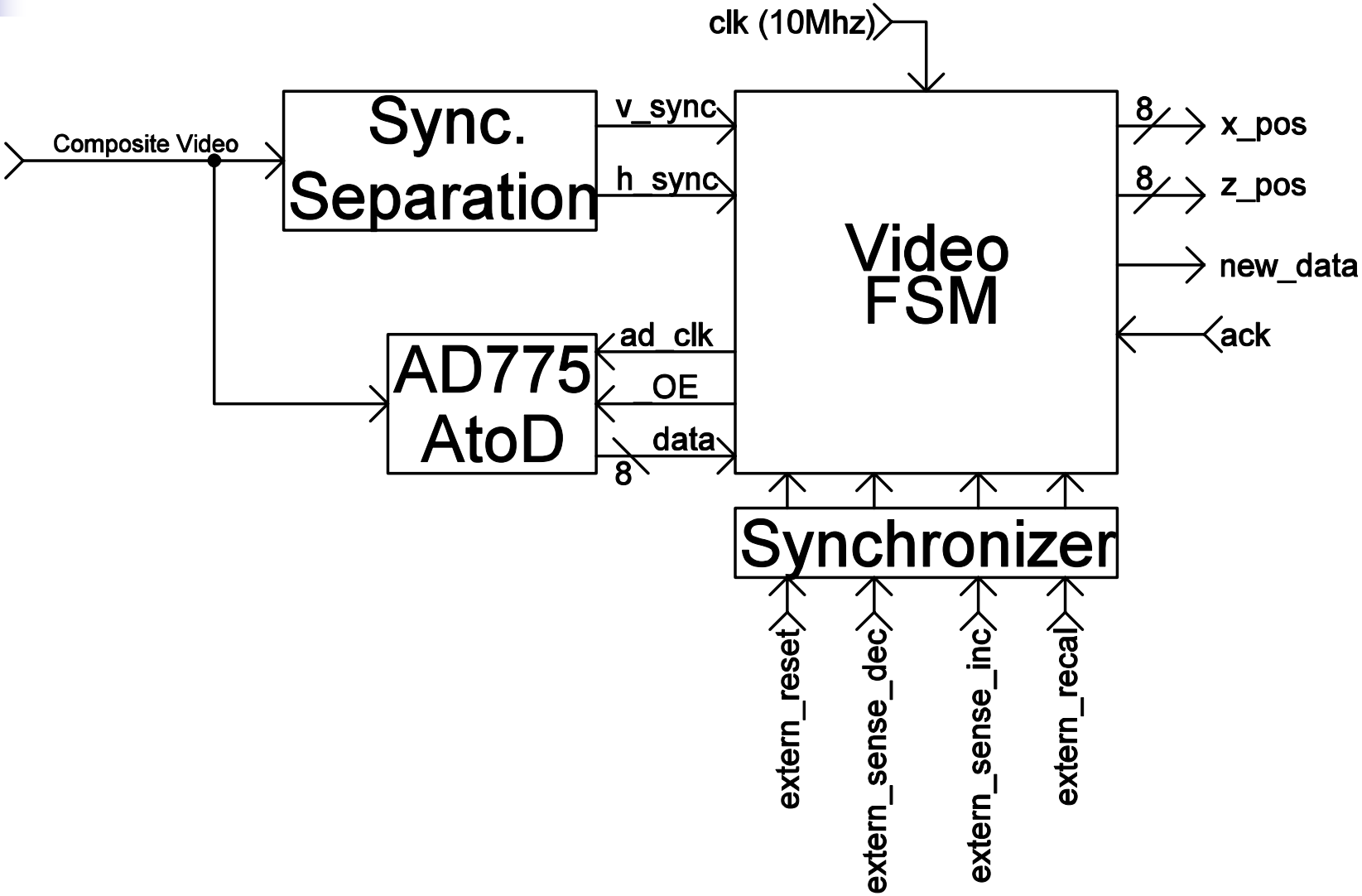
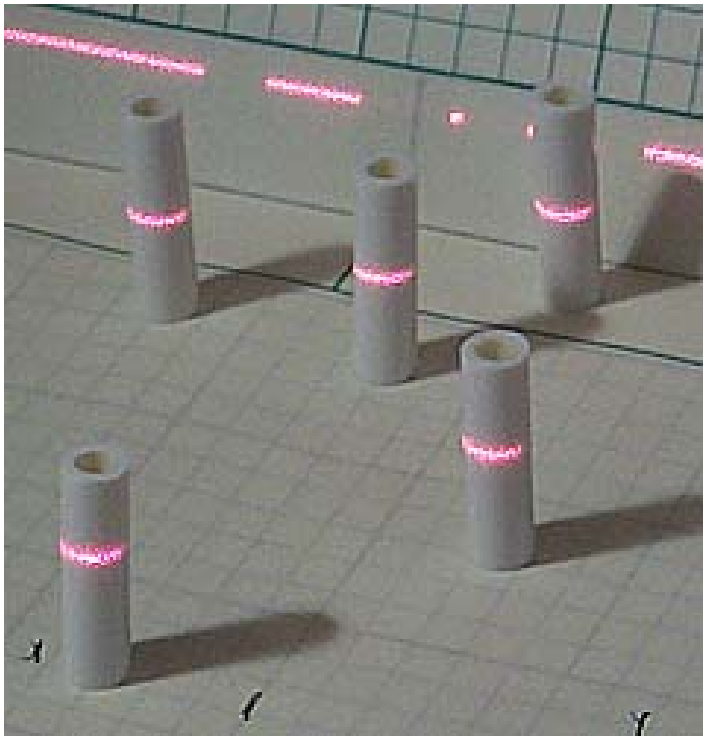


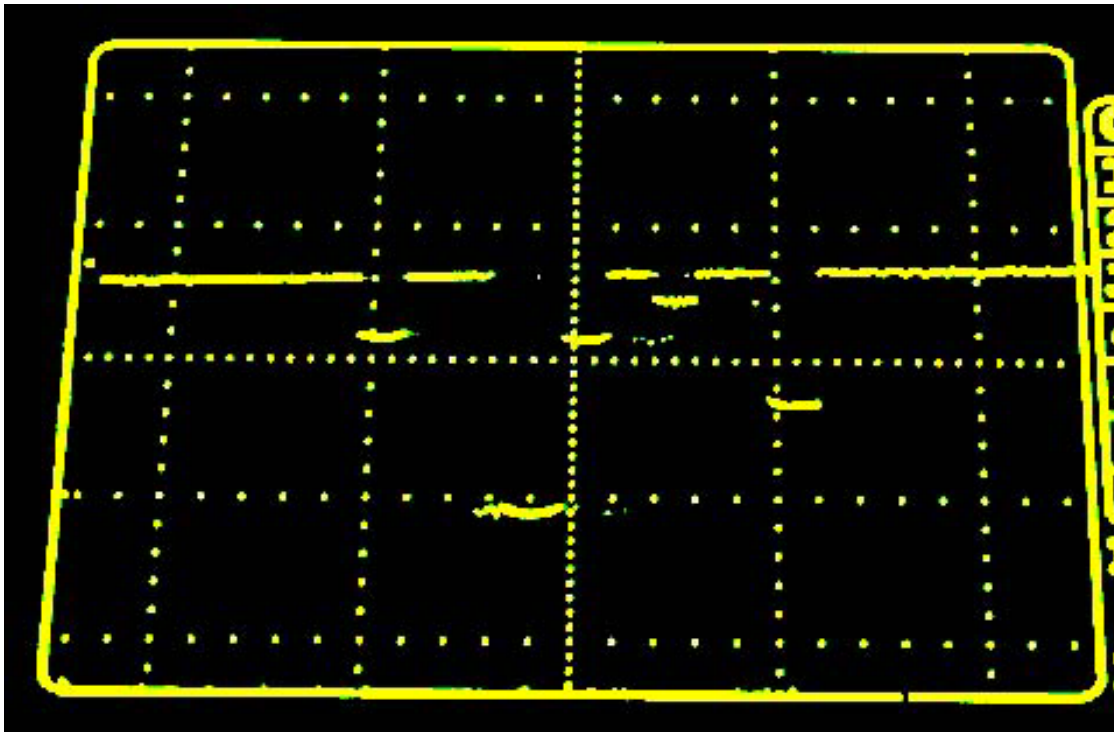
Image courtesy of Ken Maxon

Block Diagram



Example

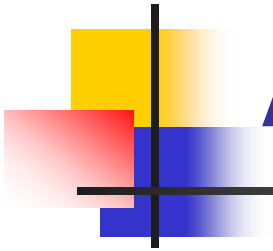




Images courtesy of Ken Maxon

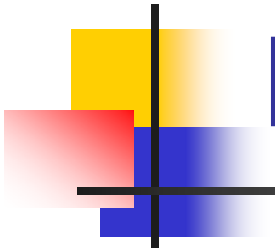
Goals

- Reliably detect the presence of the user's hand
- Accurately estimate the x- and z-coordinates of an object in the camera's field of view
- Provide a range of 64 steps on the z-axis
- Provide a range of 128 steps on the x-axis
- Exhibit sufficient noise accuracy so that the outputs vary by no more than ±1 LSB



Applications

- Robotics
  - obstacle avoidance
  - map building
- Manufacturing
  - computer chip placement
  - quality control
- Face recognition



Estimating F0

- Goal is to measure the fundamental frequency of the input source
- Constraining the input source's frequency spectrum to not change too rapidly

Autocorrelation

$$lag = length(x[k])$$

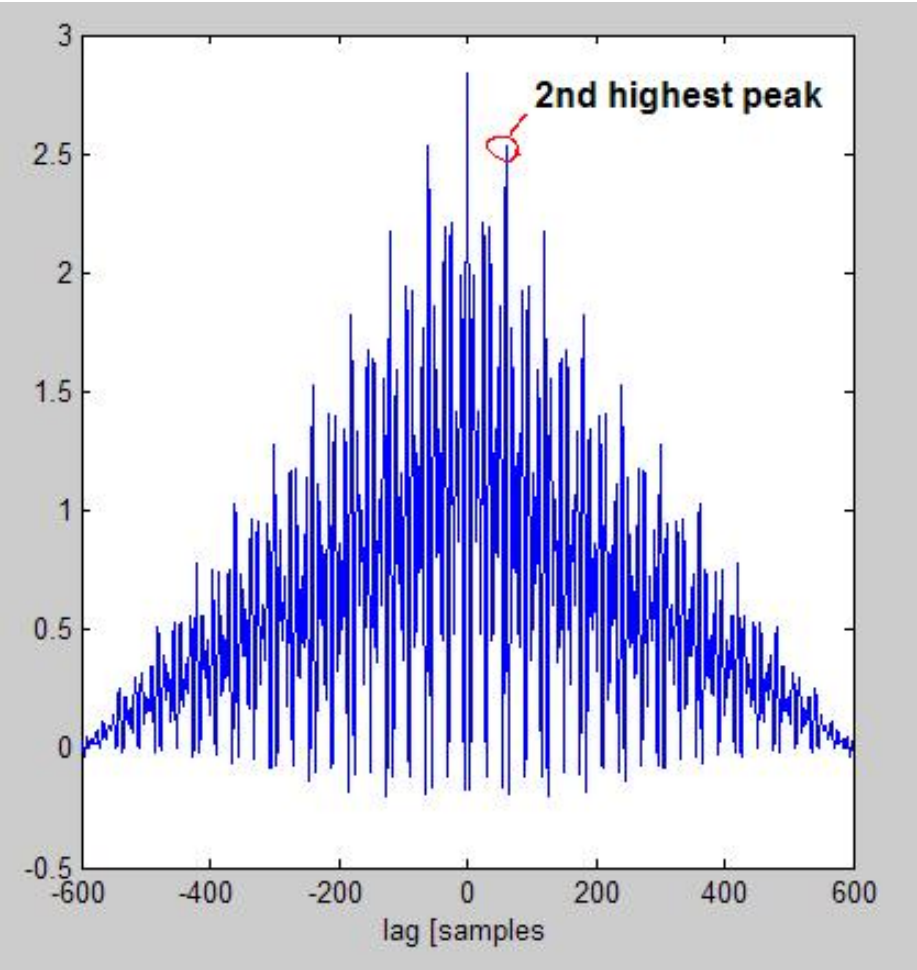
$$\sum_{lag=0} x[k]x[k-lag]$$

- Perception of periodicity is related to the time-domain.
- Idea is to measure how well the signal correlates with itself for a range of delays
- Lags corresponding to the fundamental period and the higher order resonances will correspond to the maxima

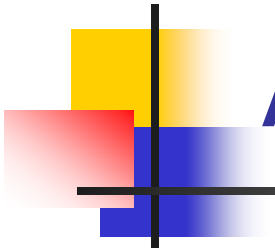
Response time

- Sampling the input signal at a rate of 40KHz
- Goal is to update the fundamental frequency every 1/10 sec.
- Using a 10 MHz clock, that allows 10^6 clock cycles to compute F0!

Autocorrelation function



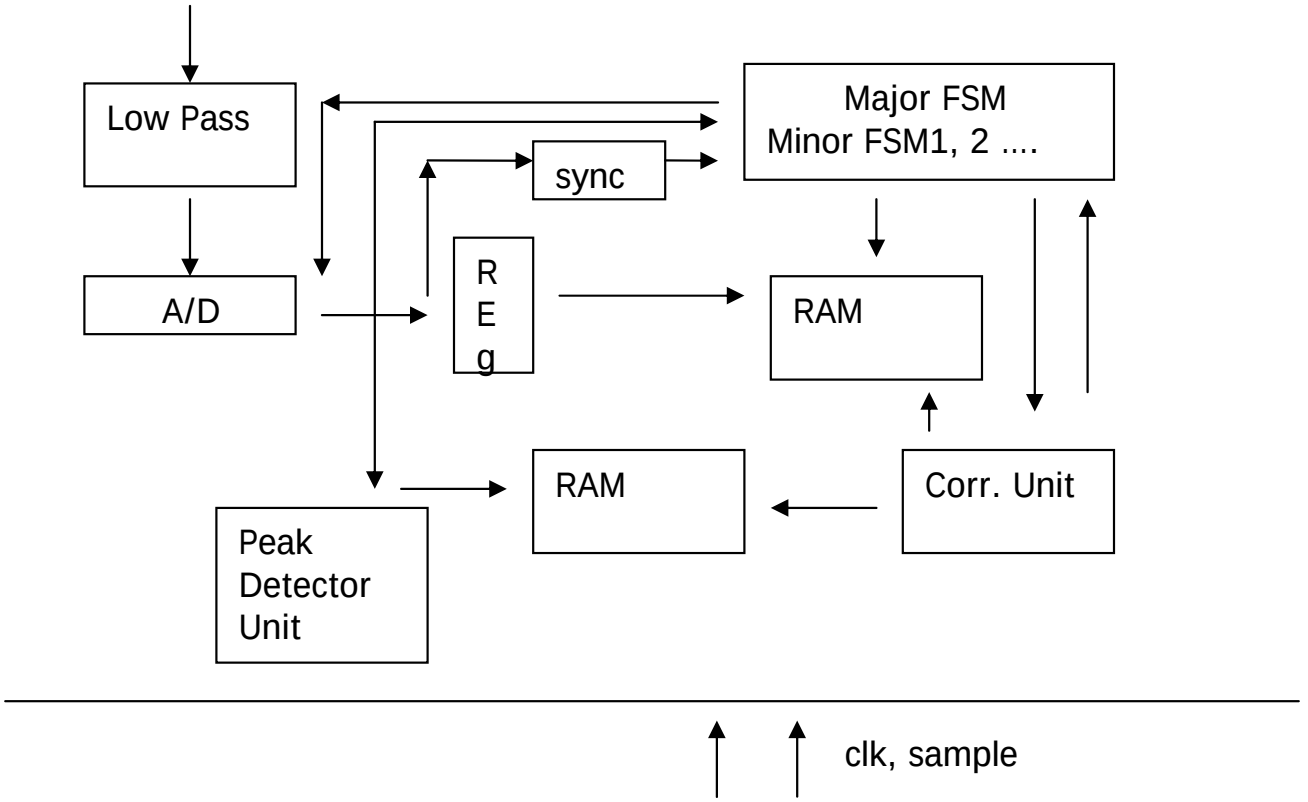
http://web.mit.edu/wonga/www/9.29/index.htm



A/D conversion

- National Semiconductor ADC12441 A/D converter
- 13-bit resolution
- 13.8us conversion time
- parallel interface
- accepts both negative and positive input voltages within any input range we define

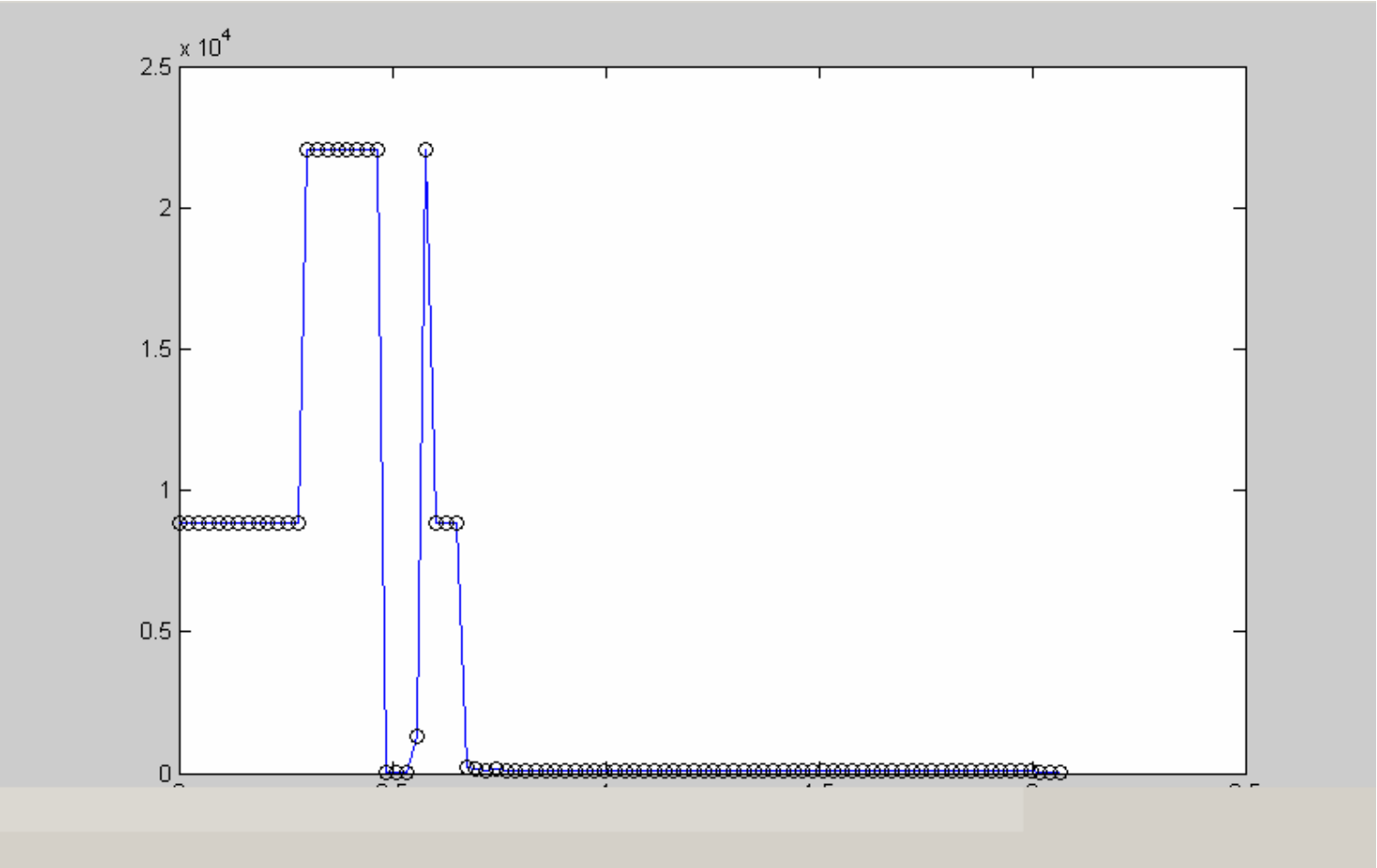
Block Diagram



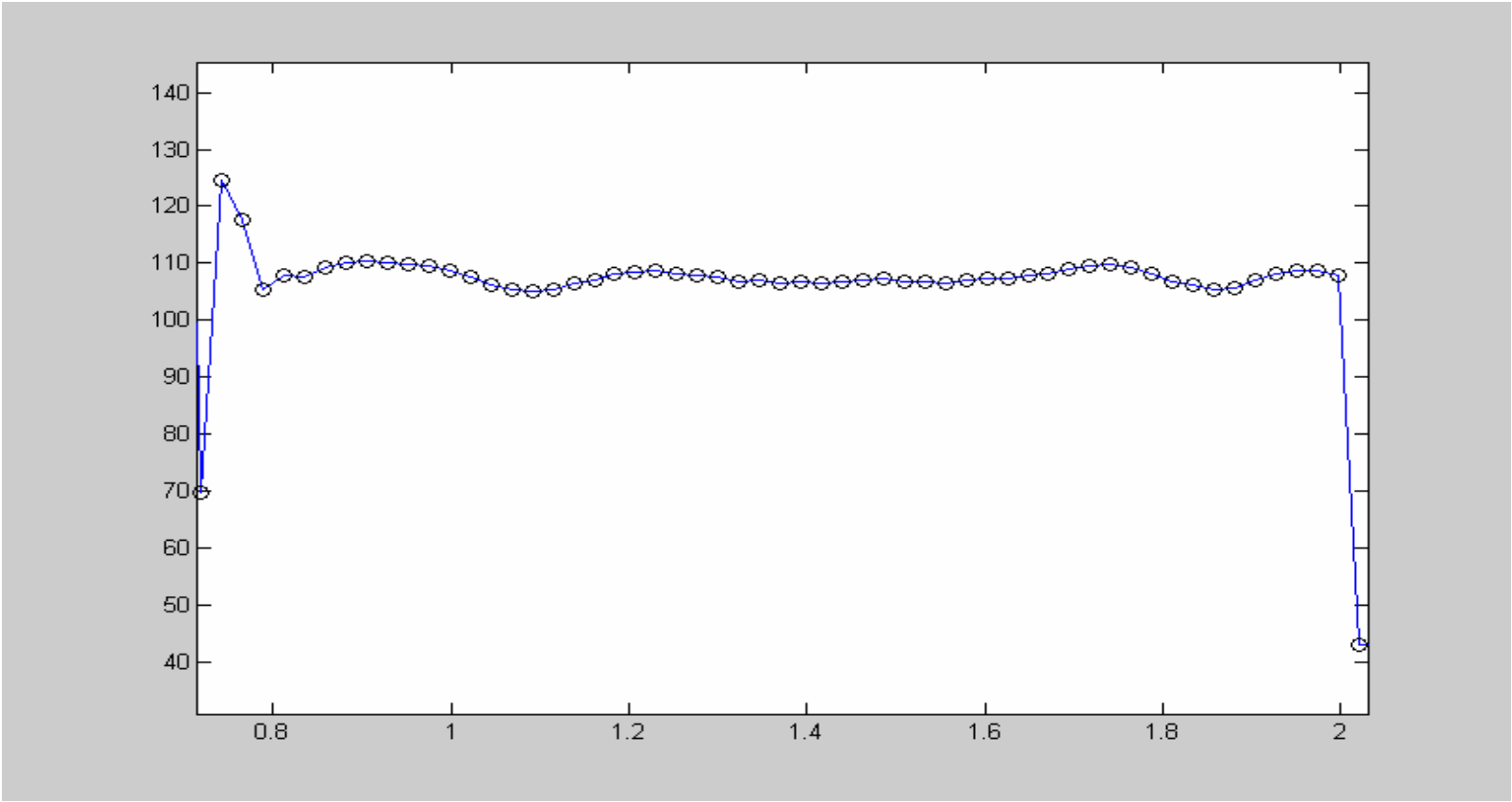
Demo

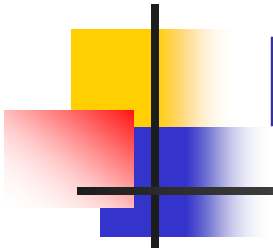
- Input source

Estimate of F0 (1)



Estimate of F0 (2)



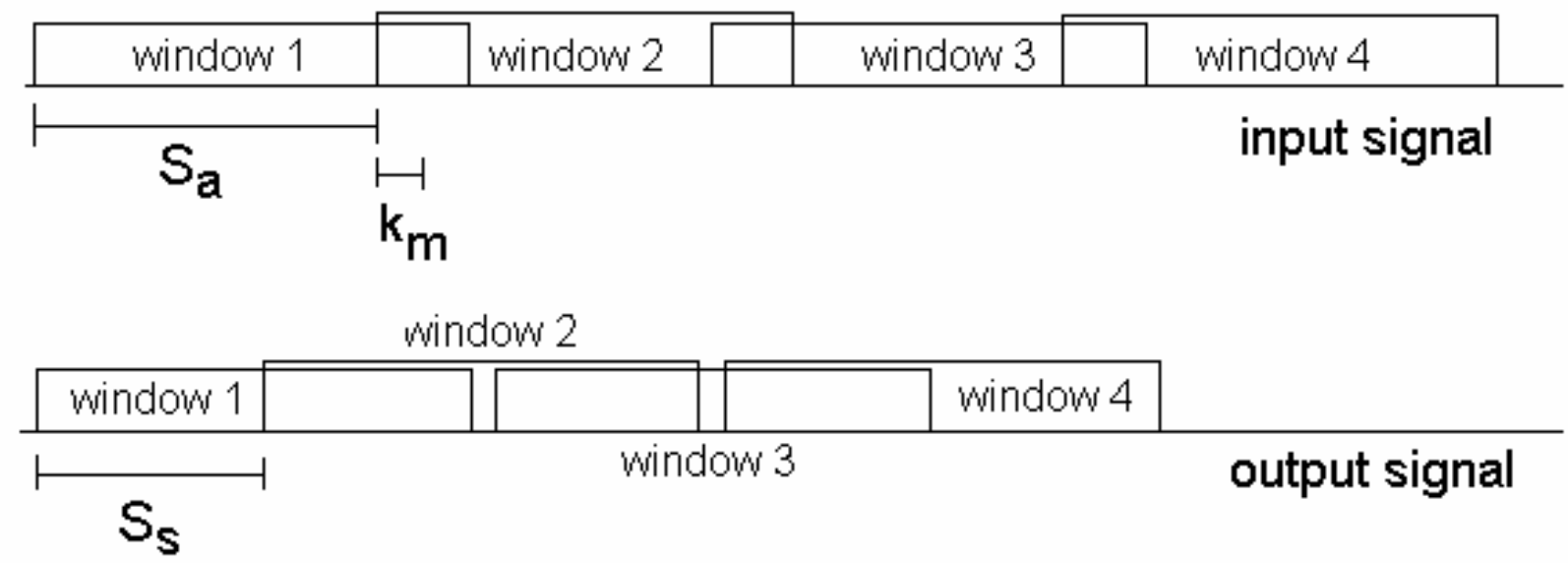


Pitch Shifting

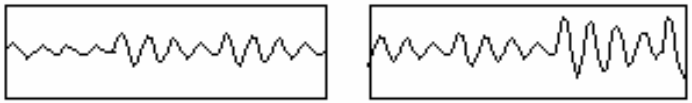
- Concept: to change pitch from f1 to f2, play back the sound at rate f2/f1.
- Problem: length of time changes.
- Solution: First expand sound sample to appropriate size, then play back at new rate.

Time Expansion/Compression

- Implemented using SOLAF – Synchronous Overlap Add at Fixed Synthesis (Don Hejna).

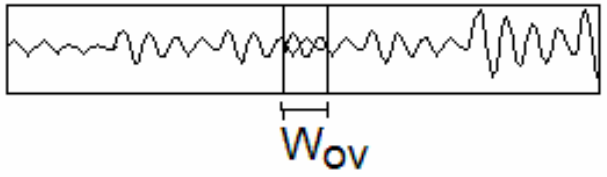


How to determine km

1. 

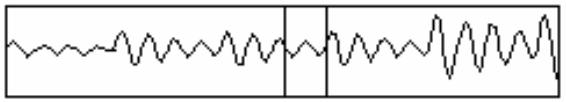
output signal

window m starting
from point m*Sa + km

2. 

compute crossign
value

3. iterate from values km = 1 to kmax

4. 

choose km with maximum
crossign value (best overlap)

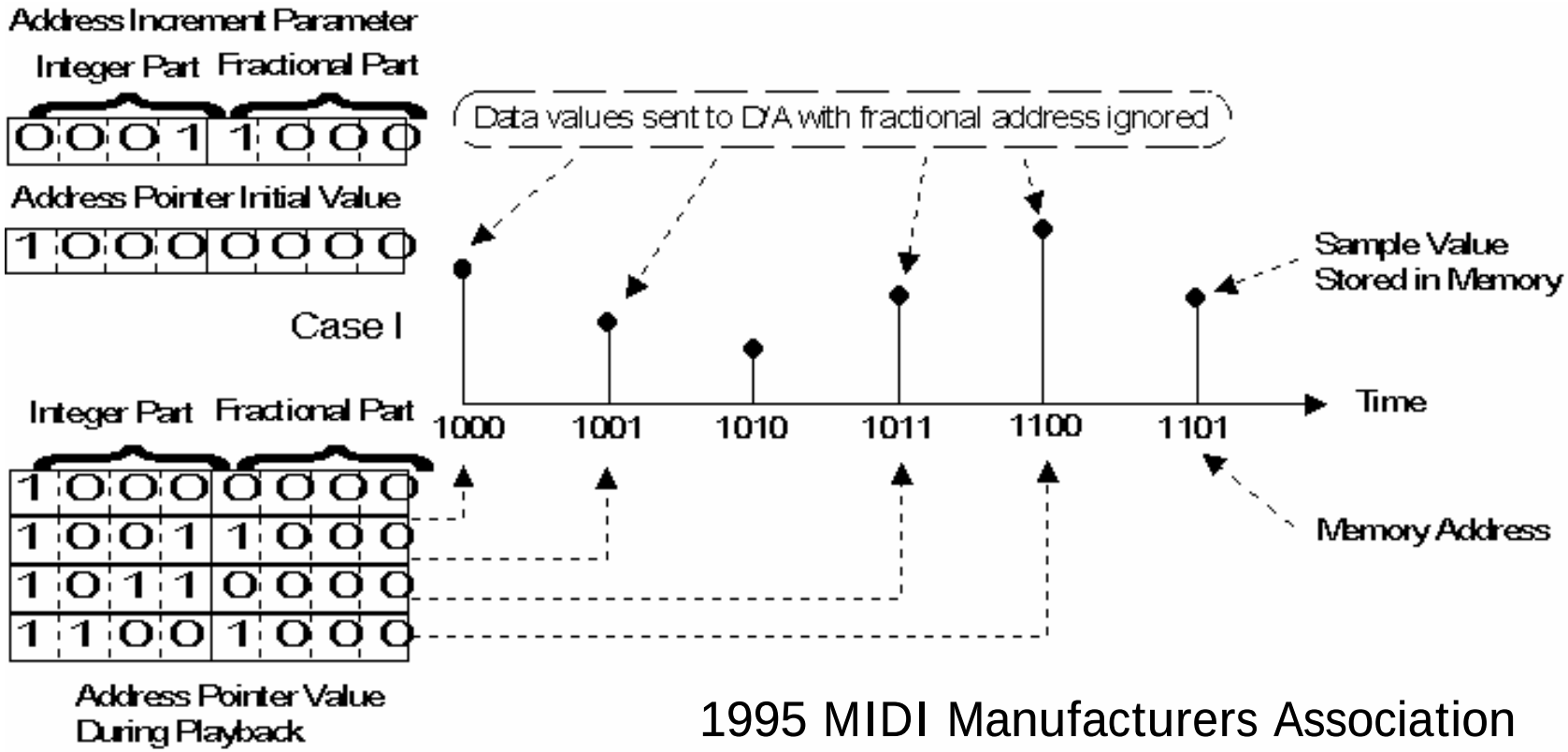
5. Add overlap region with
linear crossfade.

Crossign:
not(xor(sign bits))

Basically, if both
are positive or both
negative, + 1,
otherwise + 0.

Resampling

- Actually the sampling rate is fixed--just pick points in sound at different intervals.

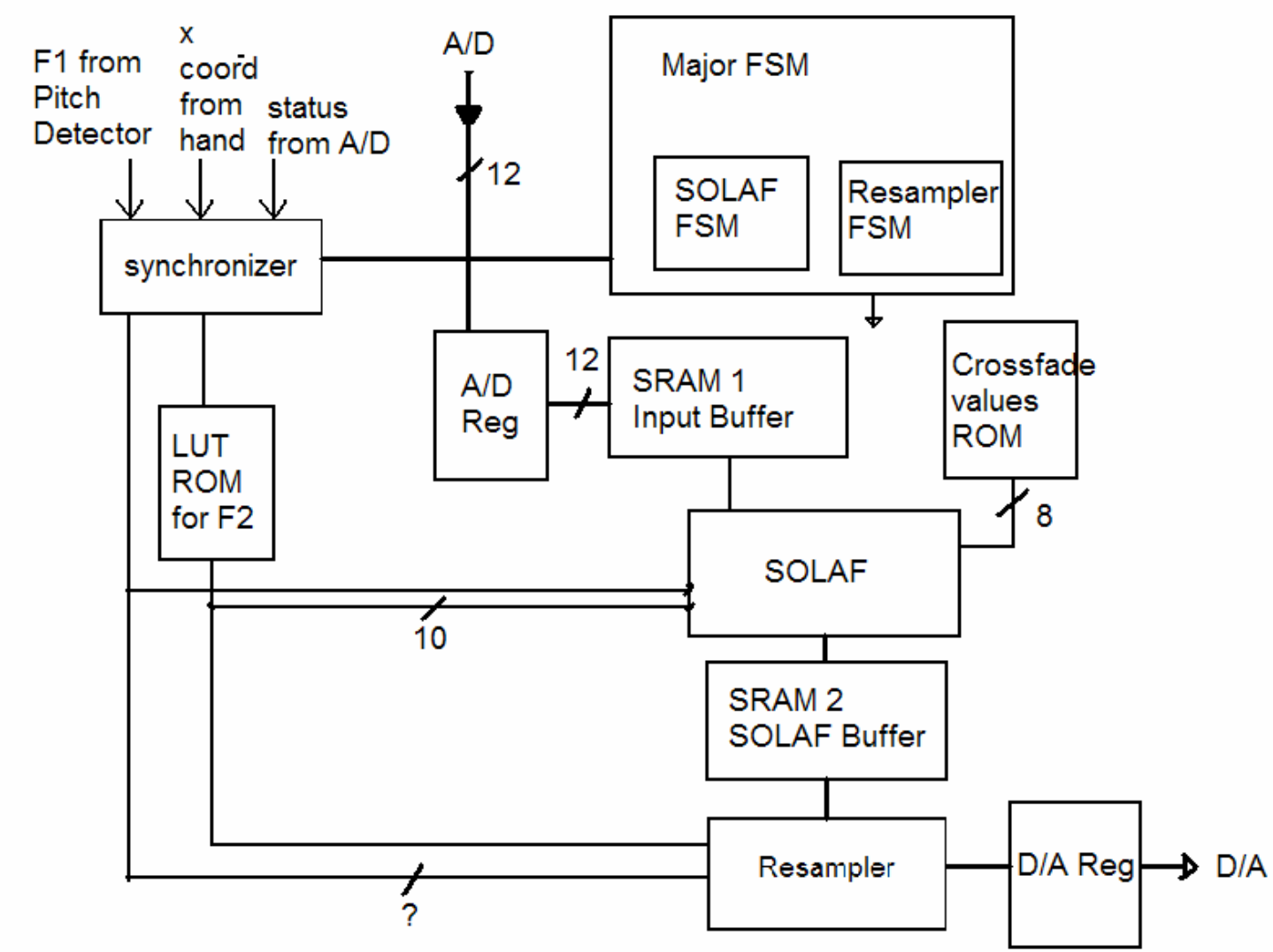


1995 MIDI Manufacturers Association

Demo

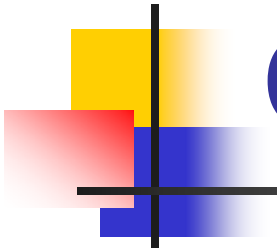
- Original, F1 is 110Hz 
- Stretched to double length 
- Played back twice rate (every other point) resulting in 220Hz 

Block Diagram



Analog Output

- 12-bit digital to analog conversion (Analog Devices AD7845)
- 4^{th} Order low-pass filter
- Digitally controlled potentiometer to control gain (Microchip MCP410XX)
- Power amplifier to drive speaker



Q/A Session