# Music Search Engine

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Advisor: Alex Spektor

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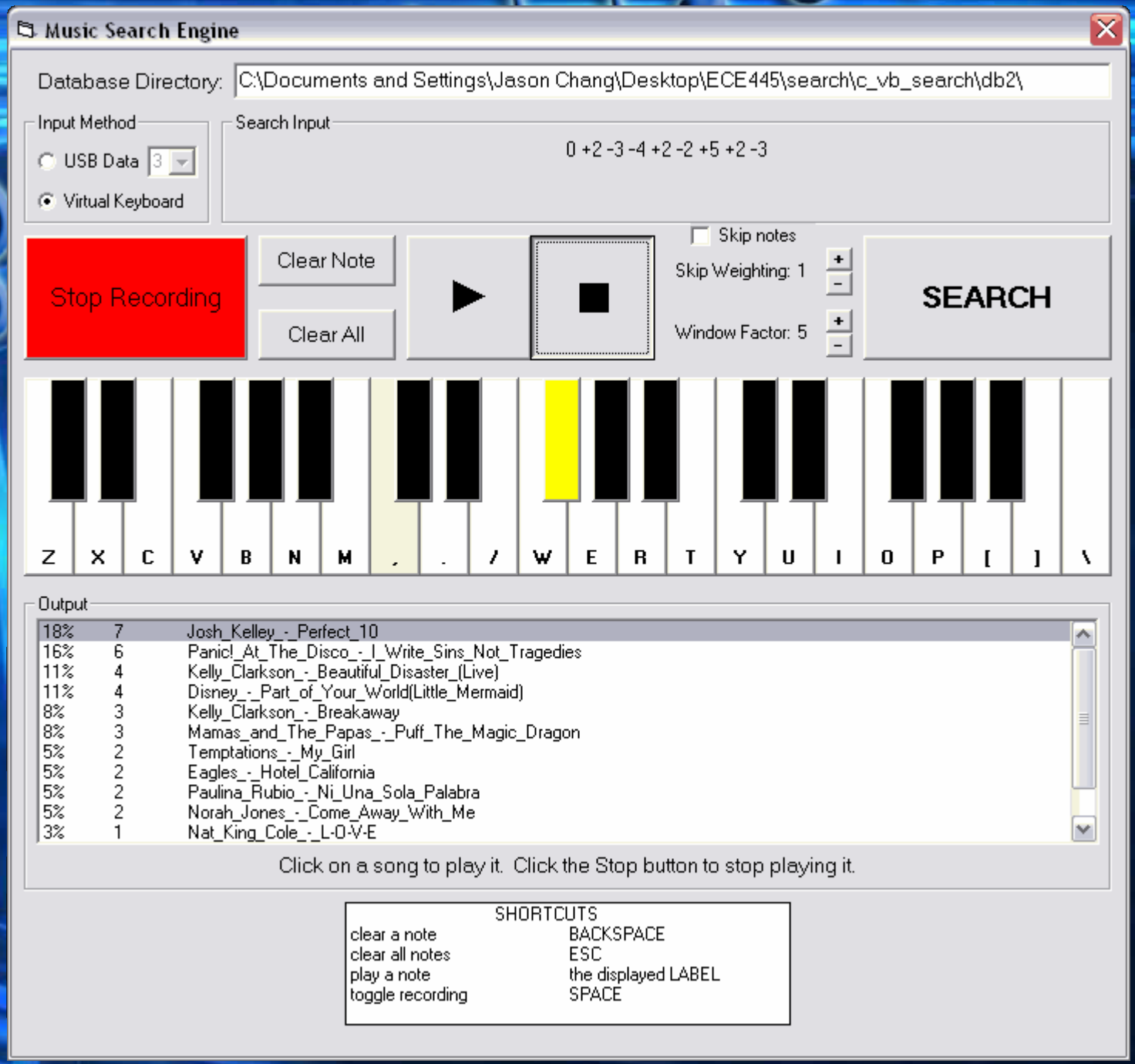
# Inspiration

- “What’s the name of that song!”
- “I can’t understand a word Enya is singing…”
- Music is a universal language

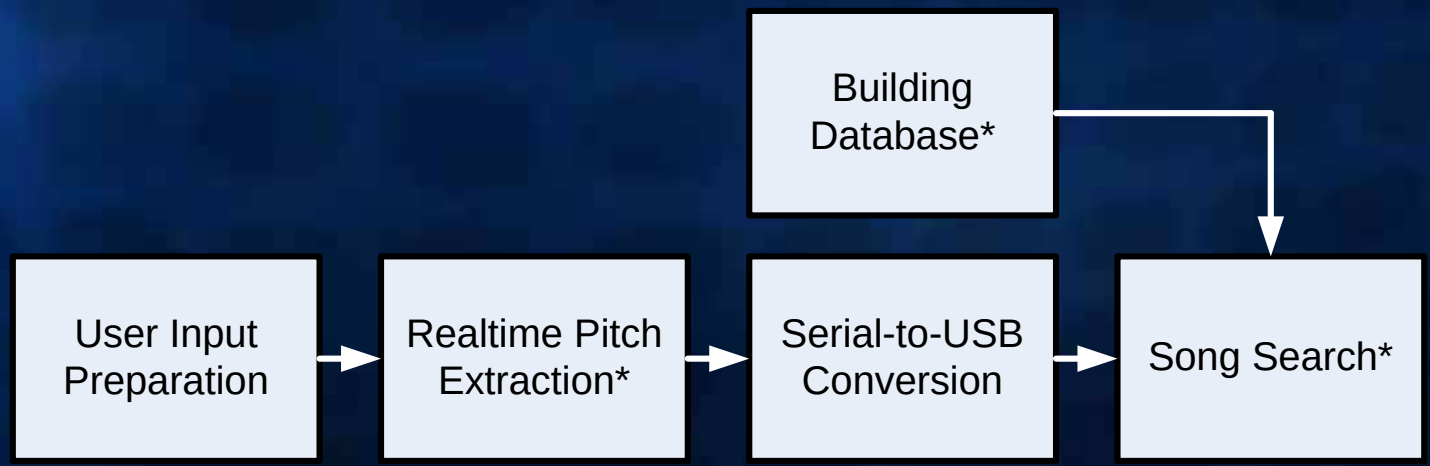
# Features

- Search song by:
  - Virtual keyboard
  - Plug in audio signal
  - Microphone input

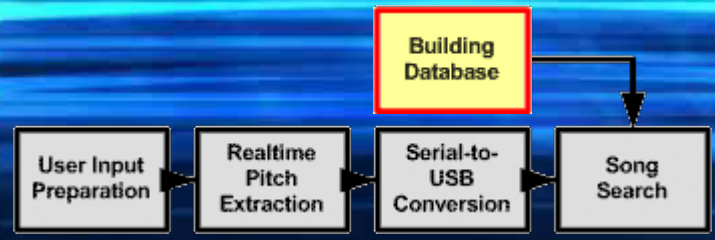

- USB Communications


Music Search Engine
Database Directory: C:\Documents and Settings\Jason Chang\Desktop\ECE445\search\c_vb_search\db2\
Input Method
USB Data 3
Virtual Keyboard
Search Input
0 +2 -3 -4 +2 -2 +5 +2 -3
Stop Recording
Clear Note
Clear All
Skip notes
Skip Weighting: 1
Window Factor: 5
SEARCH
Z X C V B N M , . / W E R T Y U I O P [ ] \
Output
18% 7 Josh_Kelley_-_Perfect_10
16% 6 Panic!_At_The_Disco_-_I_Write_Sins_Not_Tragedies
11% 4 Kelly_Clarkson_-_Beautiful_Disaster_(Live)
11% 4 Disney_-_Part_of_Your_World(Little_Mermaid)
8% 3 Kelly_Clarkson_-_Breakaway
8% 3 Mamas_and_The_Papas_-_Puff_The_Magic_Dragon
5% 2 Temptations_-_My_Girl
5% 2 Eagles_-_Hotel_California
5% 2 Paulina_Rubio_-_Ni_Una_Sola_Palabra
5% 2 Norah_Jones_-_Come_Away_With_Me
3% 1 Nat_King_Cole_-_L-O-V-E
Click on a song to play it. Click the Stop button to stop playing it.
SHORTCUTS
clear a note BACKSPACE
clear all notes ESC
play a note the displayed LABEL
toggle recording SPACE

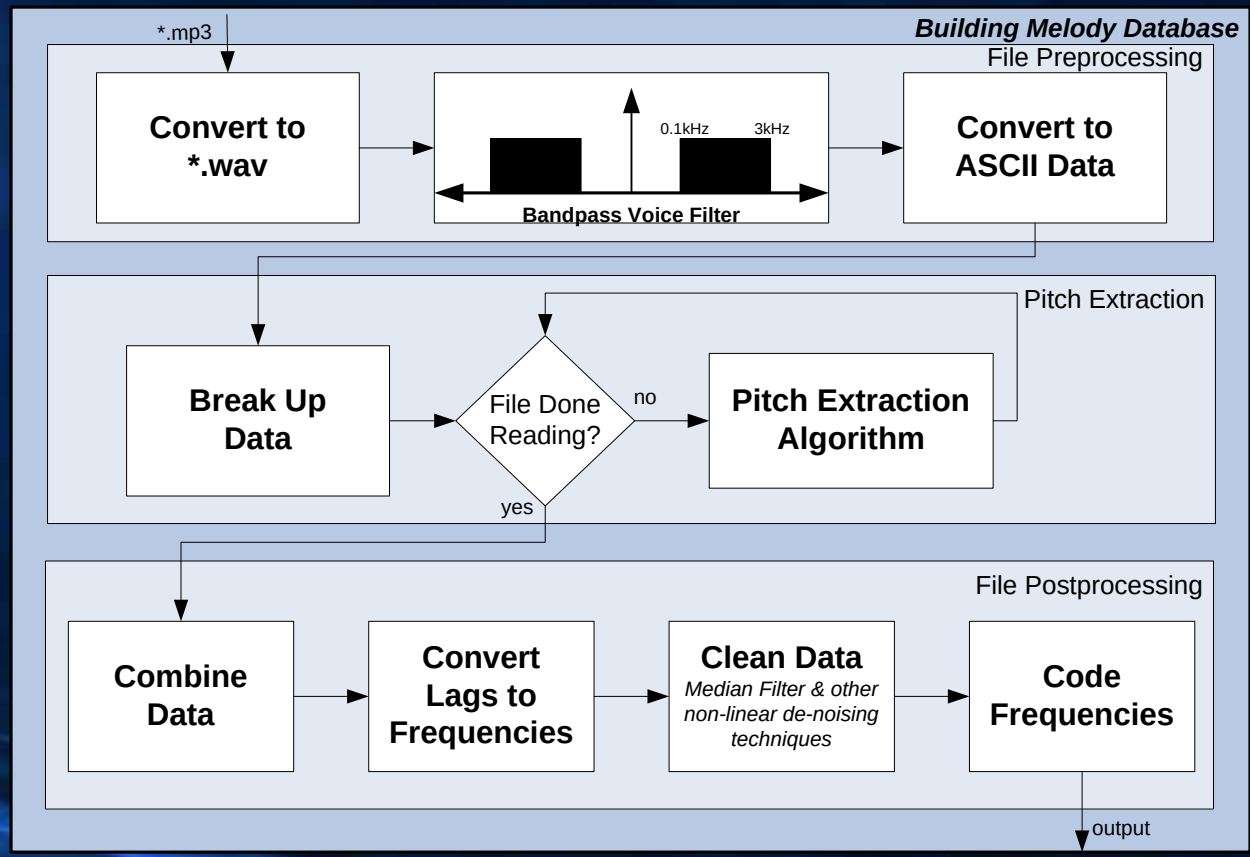
# System Details

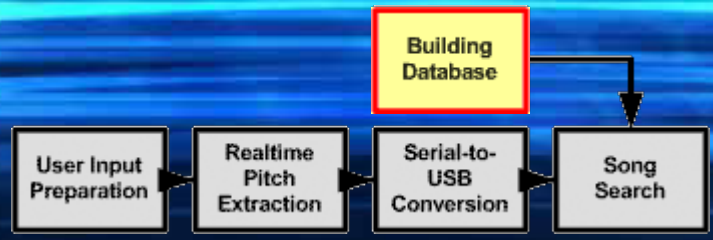



*Software Components

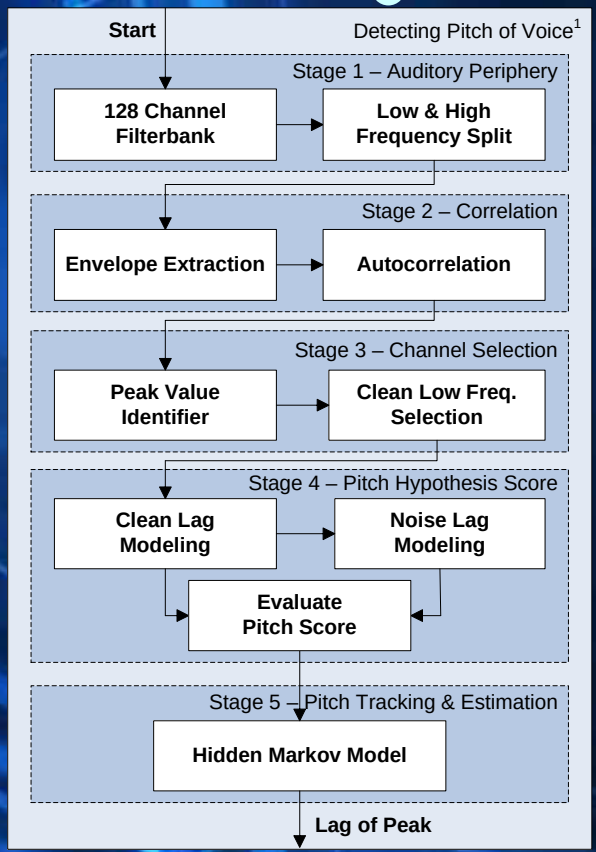



# System Details – Building Database (Overview)



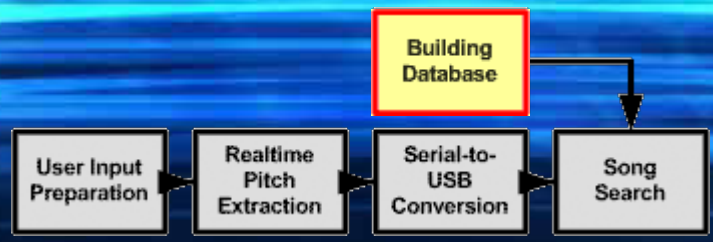



# System Details – Building Database (Algorithm)




- Implemented and Researched by Yipeng Li and DeLiang Wang[1]
- Extracts pitch perfectly at SNR = 10dB
- Typical music has SNR < 0dB
- Restricted to short input (~3 seconds)

[1] Li, Yipeng and DeLiang Wang. "Extracting Pitch of Singing Voice in Polyphonic Audio." 2005.




# System Details – Building Database (Coding)

| Key number | Note name | Frequency (Hz) |
|---|---|---|
| 44 | E4 | 329.628 |
| 43 | D#4/Eb4 | 311.127 |
| 42 | D4 | 293.665 |
| 41 | C#4/Db4 | 277.183 |
| 40 | C4 | 261.626 |
| 39 | B3 | 246.942 |
| 38 | A#3/Bb3 | 233.082 |
| 37 | A3 | 220 |
| 36 | G#3/Ab3 | 207.652 |
| 35 | G3 | 195.998 |
| 34 | F#3/Gb3 | 184.997 |
| 33 | F3 | 174.614 |
| 32 | E3 | 164.814 |
| 31 | D#3/Eb3 | 155.563 |
| 30 | D3 | 146.832 |
| 29 | C#3/Db3 | 138.591 |
| 28 | C3 | 130.813 |
| 27 | B2 | 123.471 |
| 26 | A#2/Bb2 | 116.541 |
| 25 | A2 | 110 |
| 24 | G#2/Ab2 | 103.826 |
| 23 | G2 | 97.9989 |

## Database Song Format:

| Mary Had a Little Lamb Coding Example | | | | | |
|---|---|---|---|---|---|
| Song – Freq | 329.6 | 293.7 | 261.6 | 293.7 | 329.6 |
| Song – Note | E4 | D4 | C4 | D4 | E4 |
| Song – Freq. Index | 40 | 42 | 44 | 45 | 44 |
| Song – Freq. Length (10ms) | 50 | 50 | 50 | 50 | 150 |

main

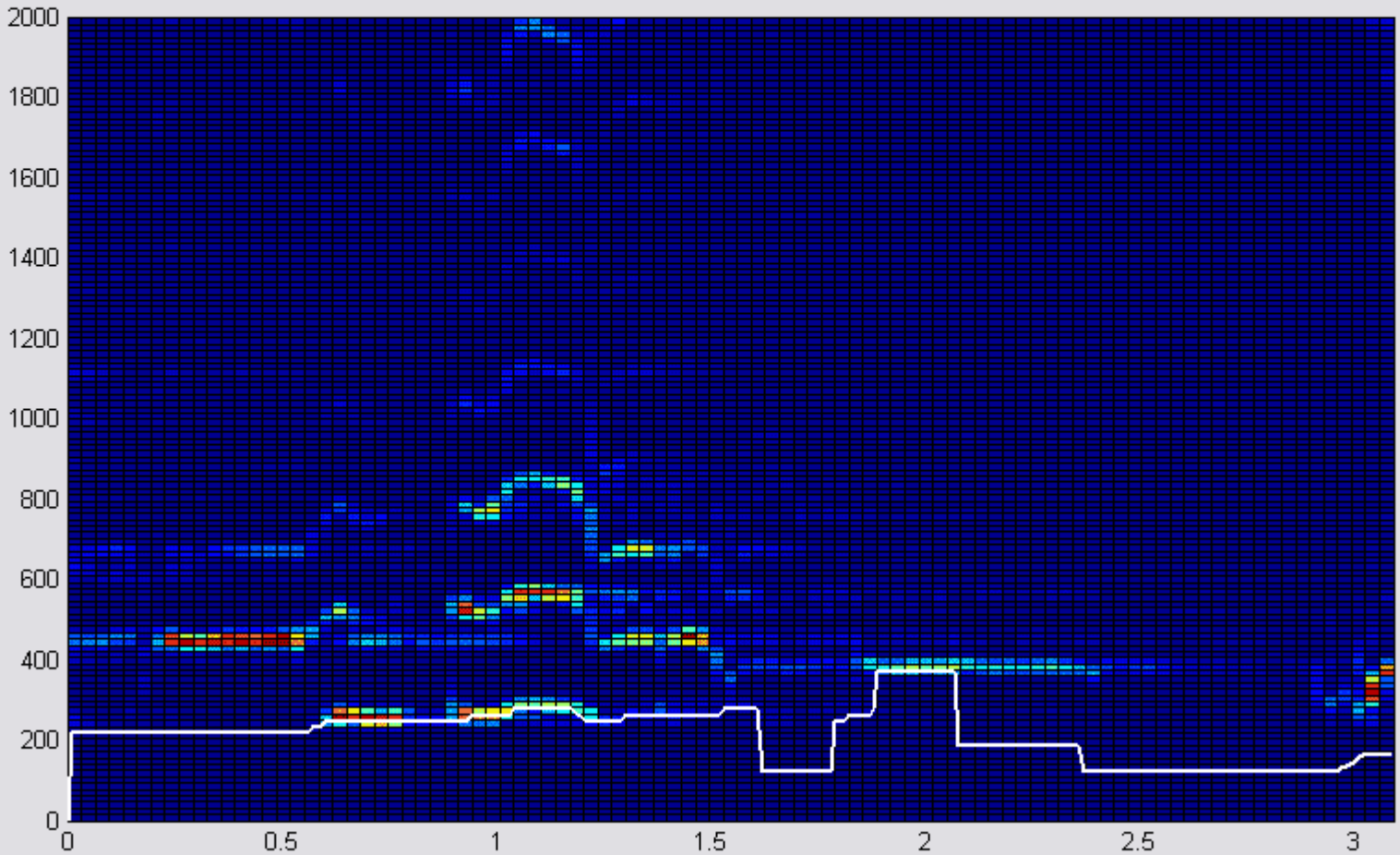
File

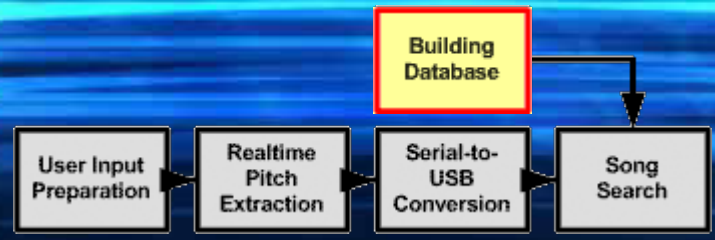
Do All Songs  Do Some Songs  1 : 1

Start  Stop

**Current Song:** 4PM - Sukiyaki
**Song Started at:** 24-Apr-2007 20:05:16
**Chunk Started at:** 24-Apr-2007 20:14:05
**Percent Done:** 11.1887

**Estimated Chunk Done at:** 24-Apr-2007 20:17:42
**Estimated Song Done At:** 24-Apr-2007 21:11:32

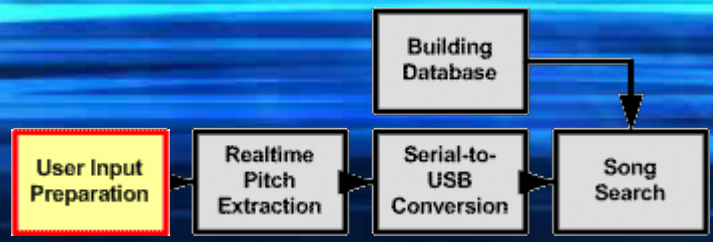





# System Details – Building Database*

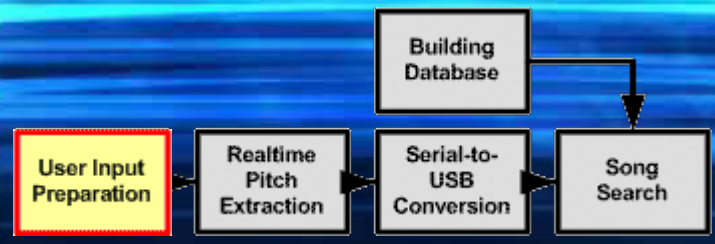
4PM – Sukiyaki
BBMak – More than Words
Billy Joel – The Longest Time
Brown Eyes – I Believe
Christina Aguilera – Beautiful
Deep Blue Something – Breakfast at Tiffany's
Dido – White Flag
Little Mermaid – Part of Your World
Eagles – Hotel California
Everclear – I Will Buy You a New Life
G.O.D. – Trip
Goo Goo Dolls – Black Balloon
Howie Day – Collide
Jackson 5 – Rockin' Robin
James Blunt – You're Beautiful
John Denver – Leaving on a Jet Plane
John Denver – Take Me Home Country Road
John Mayer – My Stuipd Mouth
Josh Kelley – Perfect 10
Kelly Clarkson – Beautiful Disaster
Kelly Clarkson – Behind These Hazel Eyes
Kelly Clarkson – Breakaway
Kelly Clarkson – Since You've Been Gone
Mamas and Papas – Puff the Magic Dragon
Mariah Carey – Hero
Mariah Carey – Can't Live if Living is Without You
Marvin Gaye – Ain't No Mountain High Enough
Michelle Branch – Are You Happy Now
Nat King Cole – L-O-V-E
Norah Jones – Come Away With Me
Norah Jones – Don't Know Why
N'Sync – How Deep is Your Love
Panic! At The Disco – I Write Sins Not Tragedies
Paul McCartney - Yesterday
Paulina Rubio – Ni Una Sola Palabra
Red Hot Chili Peppers – Otherside
Take Me Out to the Ballgame
Twinkle Twinkle Little Star
Temptations – My Girl

*Members of this group obtained legal copies of these songs



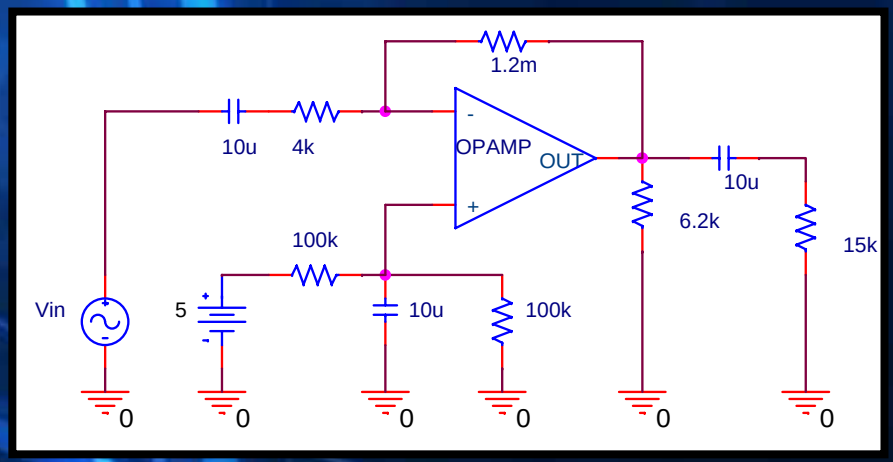

# System Details – User Input

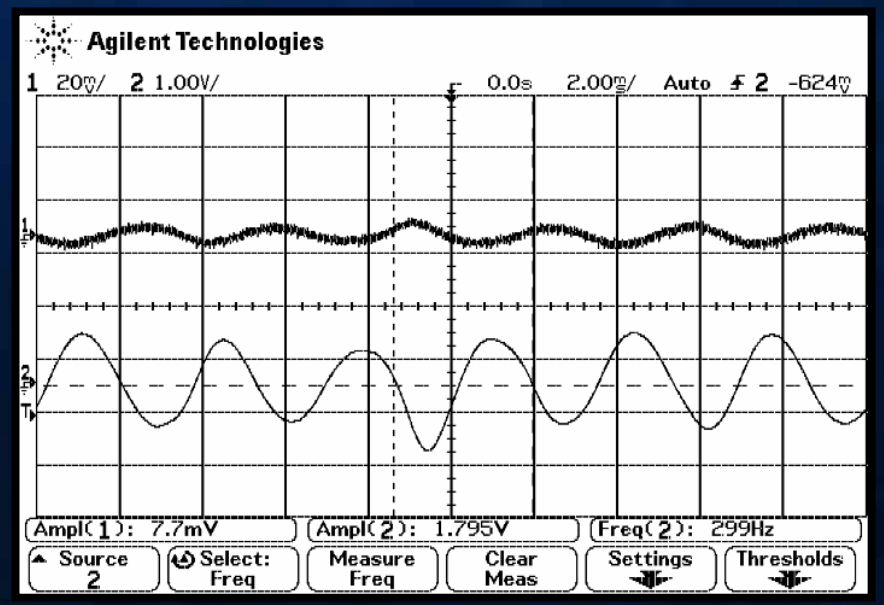
- Microphone Input
- Keyboard (Line-in) Input
- Pre-amplifier

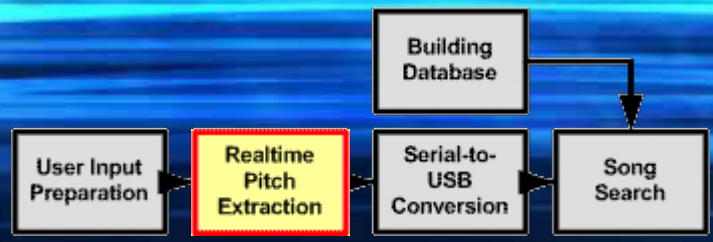



# System Details – User Input

## Preamplifier

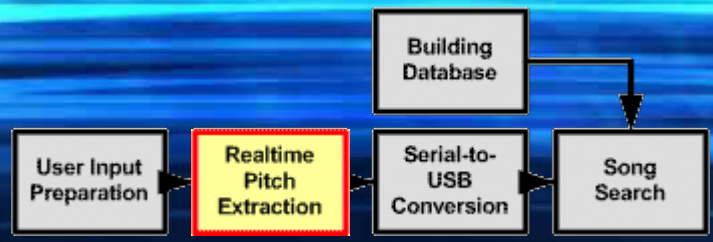




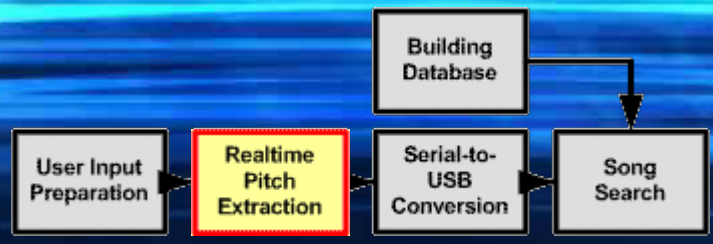

# System Details – Pitch Extraction (FFT)

- Sampling rate 44,100 Hz
- Frequency resolution 10.766 Hz
- Decimation by 8
- 4096 point FFT
- Frequency resolution 1.346 Hz



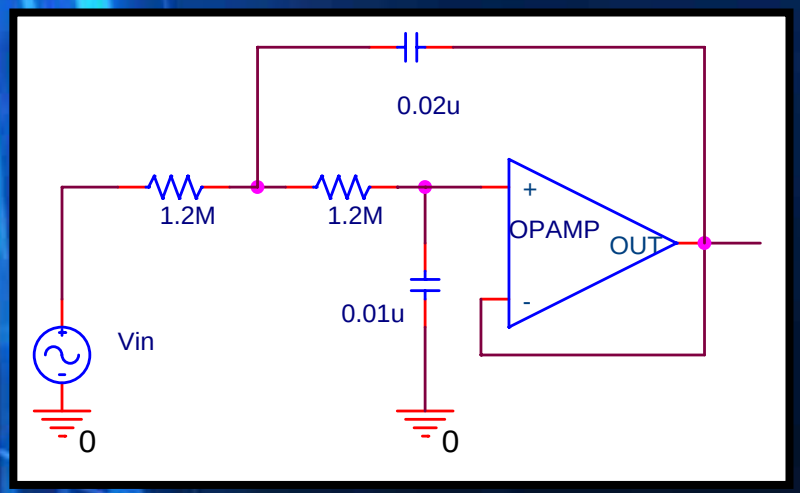

# System Details – Pitch Extraction

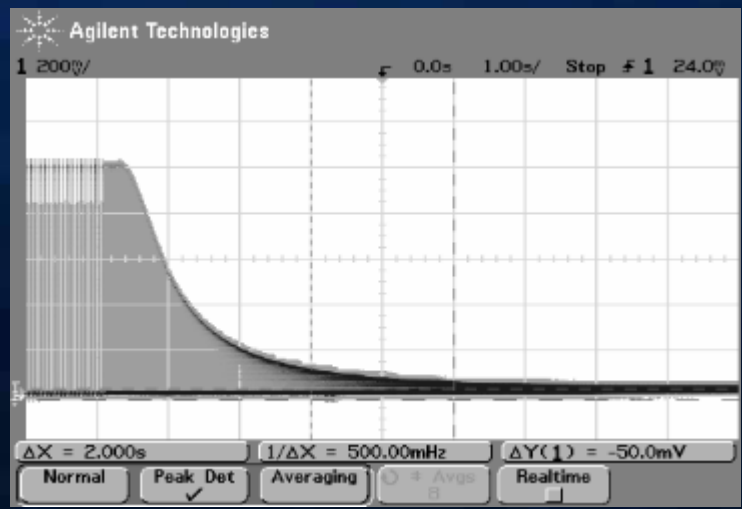
- Normal singing voice 150 – 1000 Hz
- Aliasing from harmonics
- Lowpass filter with cutoff 1000 Hz

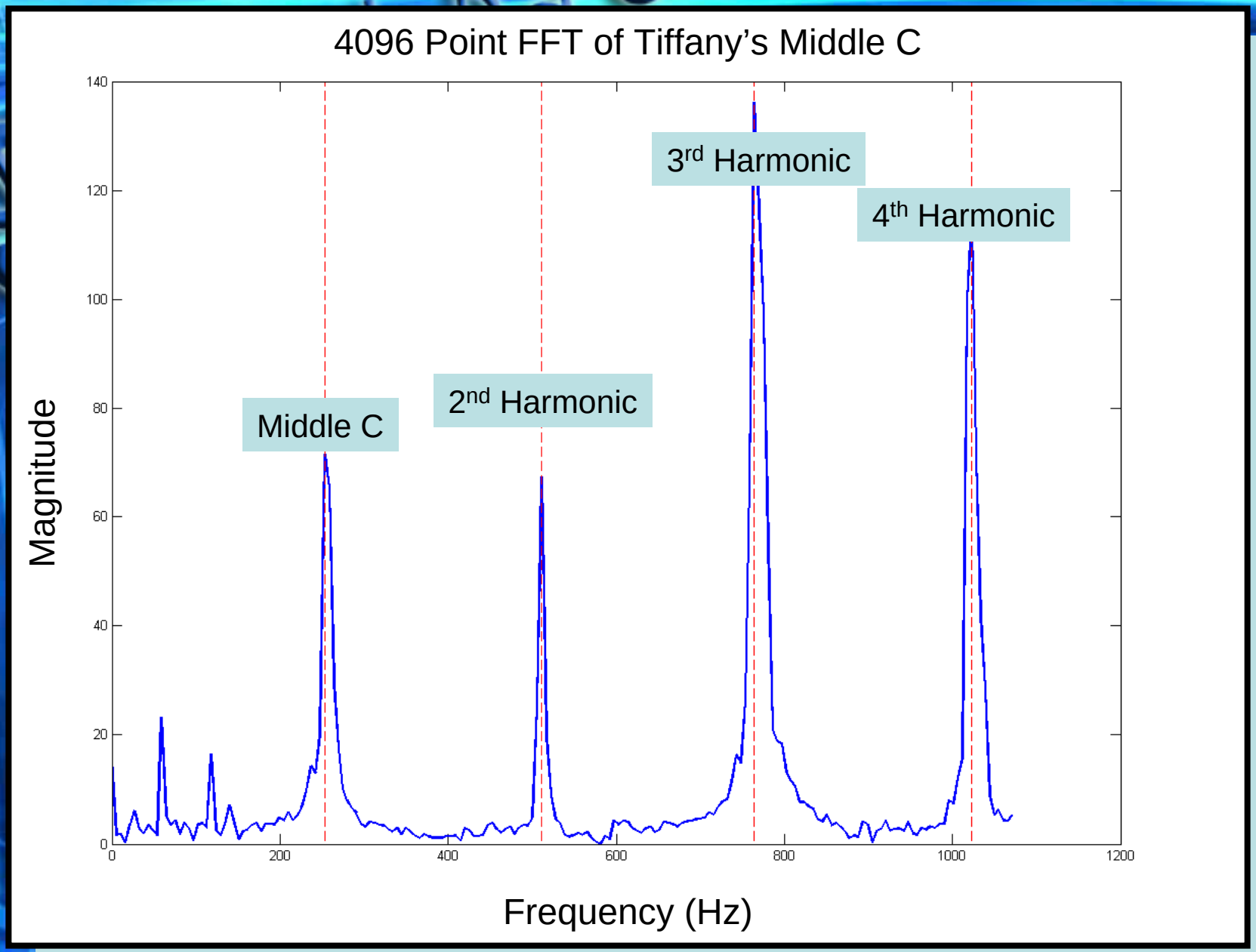


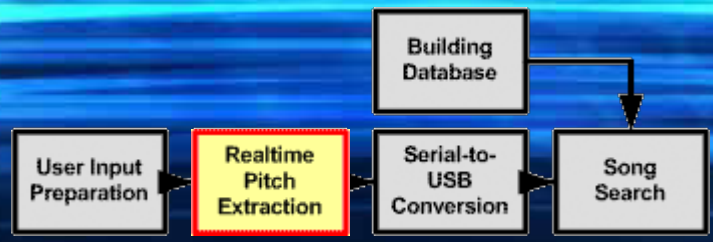

# System Details – Pitch Extraction

## Prefilter



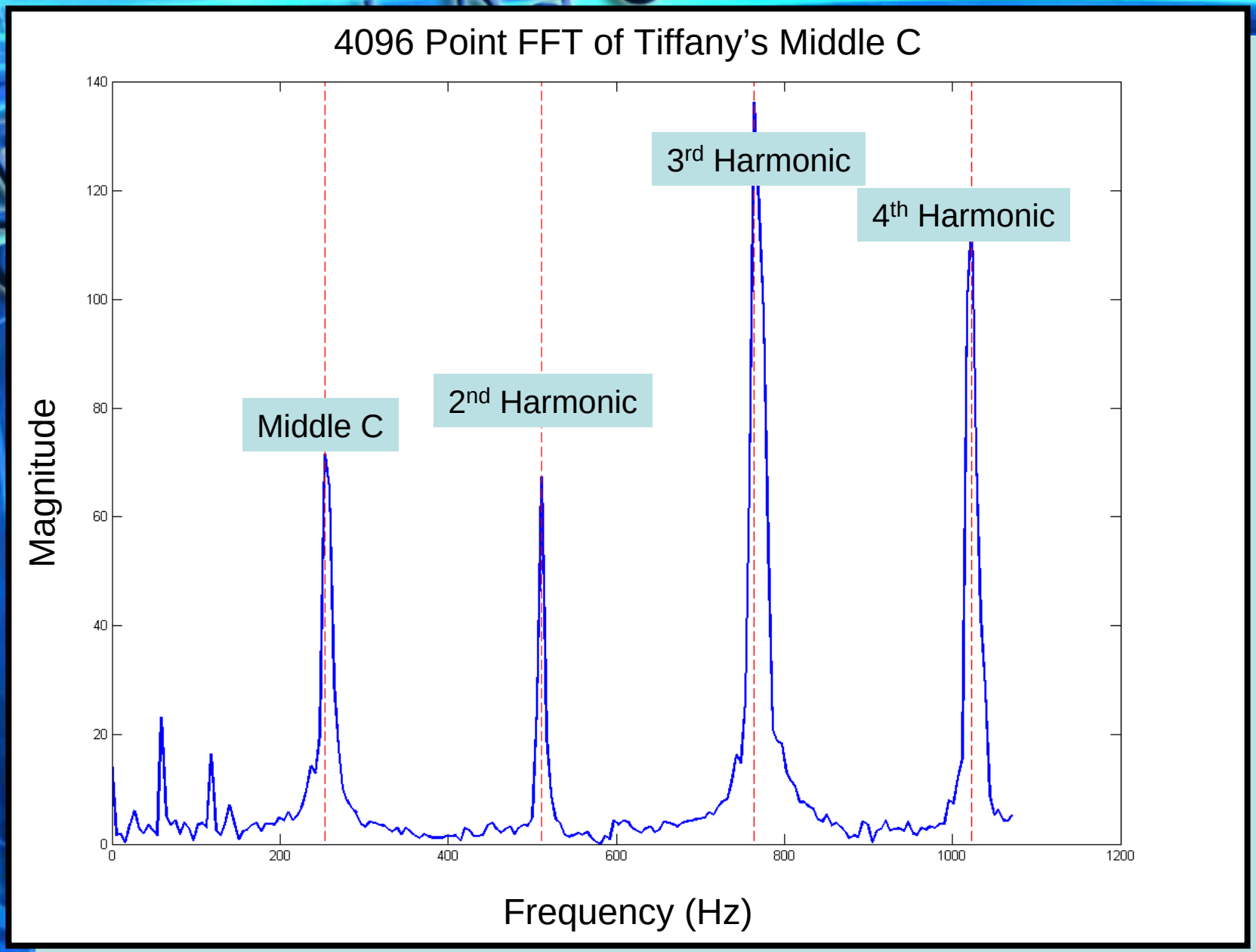



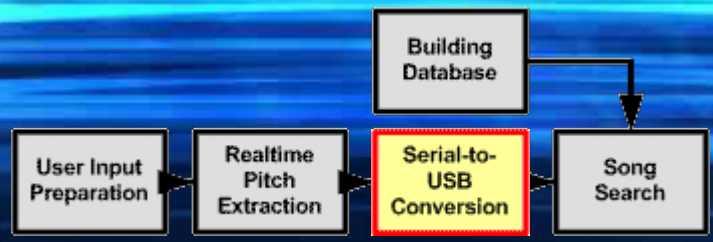

4096 Point FFT of Tiffany's Middle C
Middle C
2nd Harmonic
3rd Harmonic
4th Harmonic
Magnitude
Frequency (Hz)
0
20
40
60
80
100
120
140
0
200
400
600
800
1000
1200




# System Details – Pitch Extraction (Harmonics)

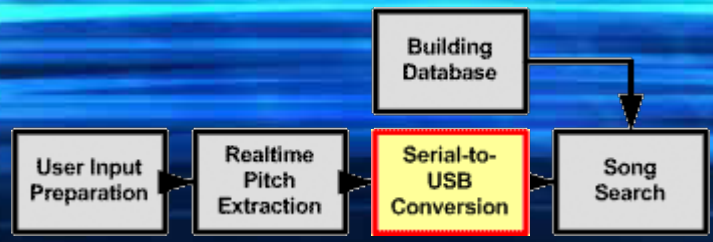
- Harmonics occur at 2x, 3x, etc., of fundamental frequency
- Harmonics of low frequency notes may fall within filtered range
- Find if strongest frequency is a harmonic of some other fundamental frequency


4096 Point FFT of Tiffany's Middle C
Middle C
2nd Harmonic
3rd Harmonic
4th Harmonic
Magnitude
Frequency (Hz)
0
20
40
60
80
100
120
140
0
200
400
600
800
1000
1200



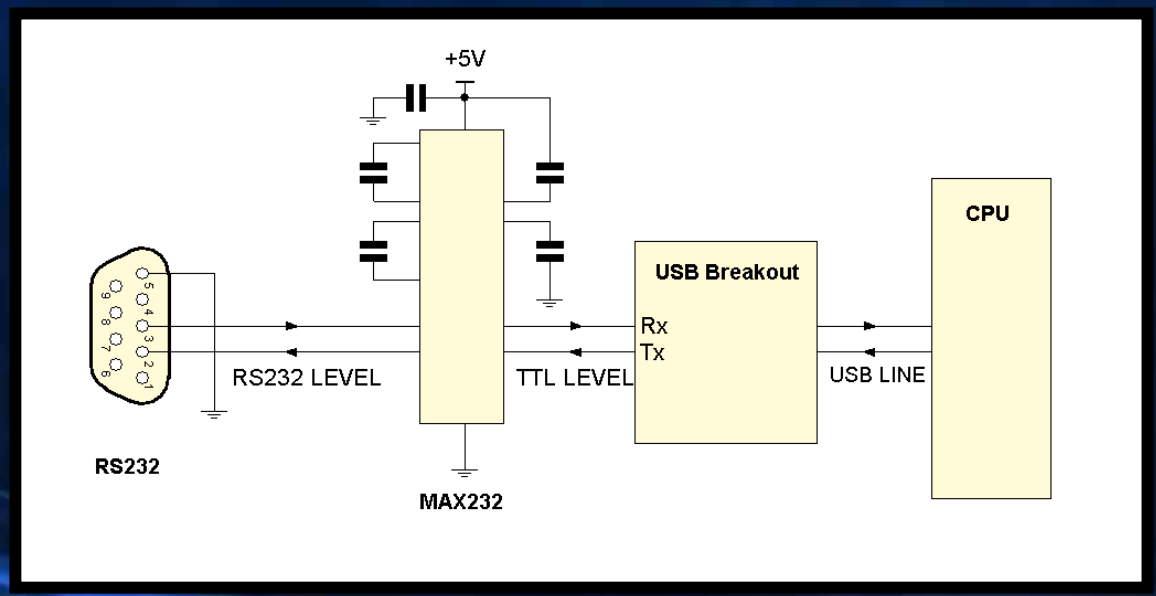

# System Details – PC Communication

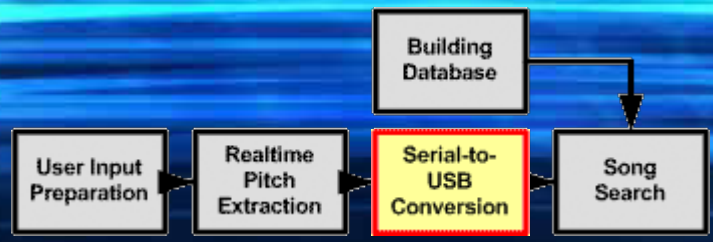
## Why serial to USB?



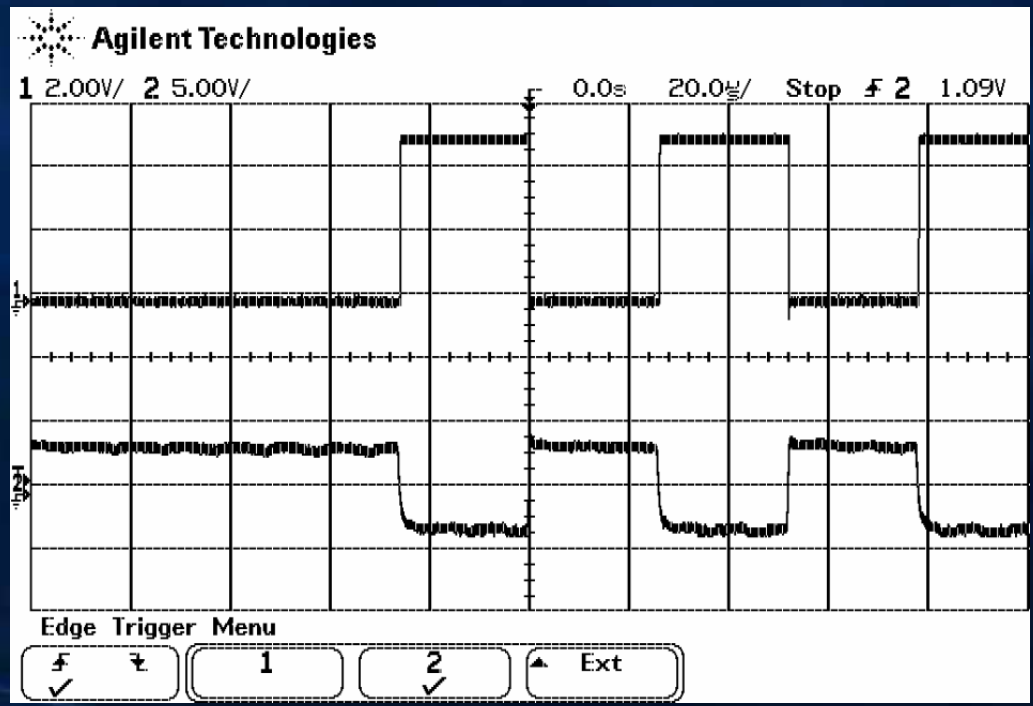

# System Details – PC Communication

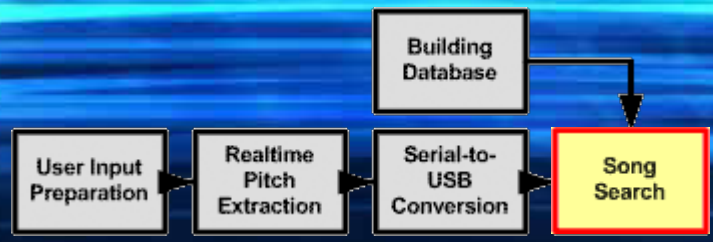
- MAX232
- USB Breakout





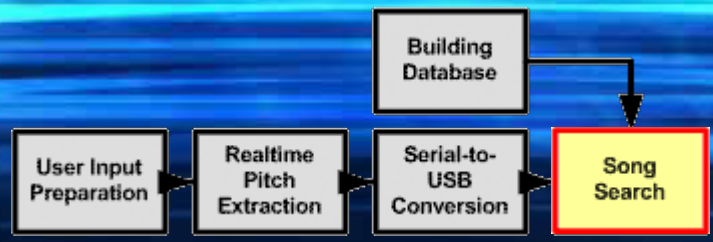

# System Details – PC Communication





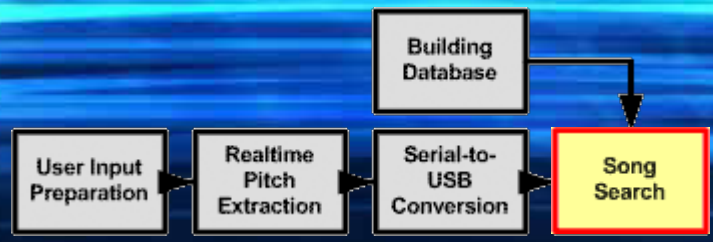

# System Details – Search Algorithm

- Hard to implement due to inaccurate database
- >5 Search Algorithms Implemented
- Optimized for quick search times and accurate results
- Search parameters effect results a great deal




# System Details – Search Algorithm

- Search window for each note
- Search window for entire string
- Possible skipping of notes




# System Details – Search Algorithm

No 44! Skip 3 notes

| Search String (differences) | 0 | +2 | +2 | +2 | +3 | +9 |
|---|---|---|---|---|---|---|

| Song – Freq. Index | 40 | 42 | 43 | 45 | 43 | 46 | 48 | 49 | 48 | 49 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Song – Freq. Length (10ms) | 20 | 20 | 5 | 5 | 5 | 5 | 10 | 10 | 10 | 10 | 10 |

# Testing & Results

- Perfect database & perfect input = perfect
- Bad database & perfect input = pretty good
- Bad database & bad input = not good

- Perfect database – Hard coded database
- Perfect input – Virtual keyboard

# Testing & Results

| Search | Language | <Search Time/ N> | <Percent of finding song> |
|---|---|---|---|
| Split Block Search | VB6 | 10.4ms | 56.0% |
| Split Block Search (with Error Factor) | VB6 | 12.5ms | 54.0% |
| Complete Window Search | VB6 | 152.6ms | 48.0% |
| Complete Window Search (with Error Factor) | VB6 | 165.4ms | 70.7% |
| Complete Window Search | C++ & VB6 | 16.4ms | 68.6% |
| Complete Window Search (with Skip) | C++ & VB6 | 20.4ms | 83.6% |

N: input string length

**Songs Tested**

**Deep Blue Something –** Breakfast at Tiffany's
**Mamas and Papas –** Puff the Magic Dragon
**Paulina Rubio –** Ni Una Sola Palabra
**Dido –** White Flag
**Norah Jones –** Come Away with Me
**Red Hot Chili Peppers –** Otherside
**Josh Kelley –** Perfect 10
**Paul McCartney –** Yesterday

# Conclusions

Advantages

- Can search vast database
- Potentially retrieve similar music

Disadvantages

- Never as perfect as human
- Each song takes a long time to process

# Conclusions

Future improvement

- Improve database algorithm
- Recognize and stabilize wavering from untrained singers
- Improve search algorithm – leniency for imperfect input

# Thank You…

- Professor Swenson
- Alex Spektor & ECE445 TAs
- ECE Shop Technicians
- Yipeng Li & DeLiang Wang
- Professor Jones
- TI Support

# References


[1] Li, Yipeng and DeLiang Wang. “Extracting Pitch of Singing Voice in Polyphonic Audio.” 2005.

[2] Li, Yipeng and DeLiang Wang. “Singing Voice Separation from Monaural Recordings.” 2006.

[3] Shandilya, Saurabh Kumar and Preeti Rao. “Retrieving Pitch of Singing Voice in Polyphonic Audio.” 2006.

[4] Texas Instruments. Quadruple Operational Amplifiers. January 2005. http://focus.ti.com/lit/ds/symlink/lm324.pdf

[5] Maxim-IC. +5V-Powered, Multichannel RS-232 Drivers/Receivers. January 2006. http://pdfserv.maxim-ic.com/en/ds/MAX220-MAX249.pdf

[6] Spark Fun Electronics. Breakout Board for CP2102 USB to Serial. http://www.sparkfun.com/commerce/product_info.php?products_id=198

[7] eCircuit Center. “Sallen-Key Low-Pass Filter”. 2002. http://www.ecircuitcenter.com/Circuits/opsalkey1/opsalkey1.htm

# Thank you for coming!

Questions?