Image taken from http://www.musicteachershelper.com

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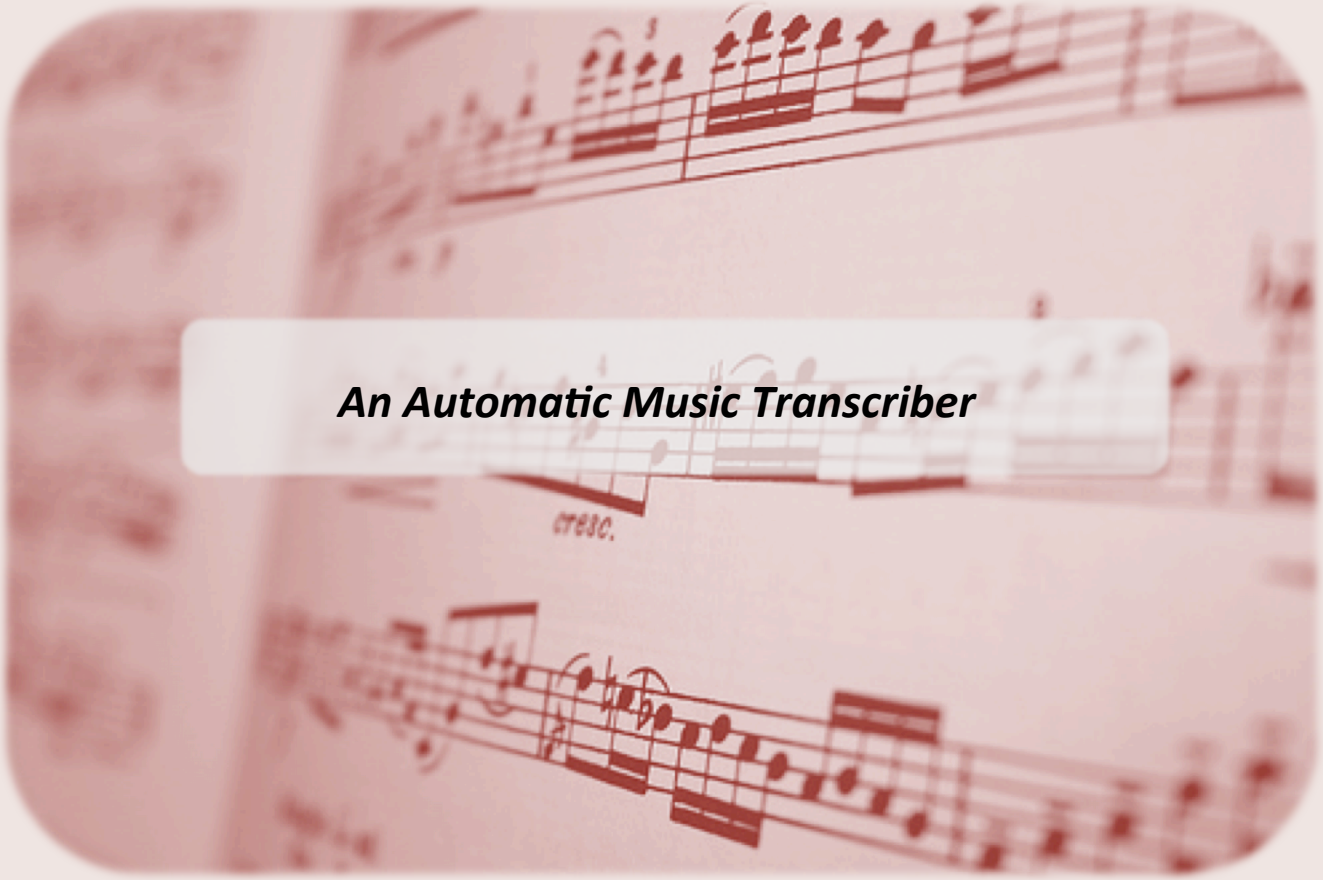
The AutoTab



An Automatic Music Transcriber

The ScribeWare Team

Mike Tyson: *Chief Executive Officer*

Henry Huang: *Chief Technical Officer*

Patrick Wong: *Chief Financial Officer*

Shu Hui Wong: *Chief Operating Officer*

Team Dynamics

- Well defined roles and responsibilities
  - Mike and Patrick: Software implementation and testing
  - Henry: Hardware implementation and testing
  - Shu Hui: Documentation
- Everyone helped with other areas when needed

Outline

- Introduction
- System Overview
- Market Analysis
- Budget and Timeline
- Hardware
- Musical Theory
- Software
- Future Development
- Lessons Learnt
- Conclusion
- Acknowledgements

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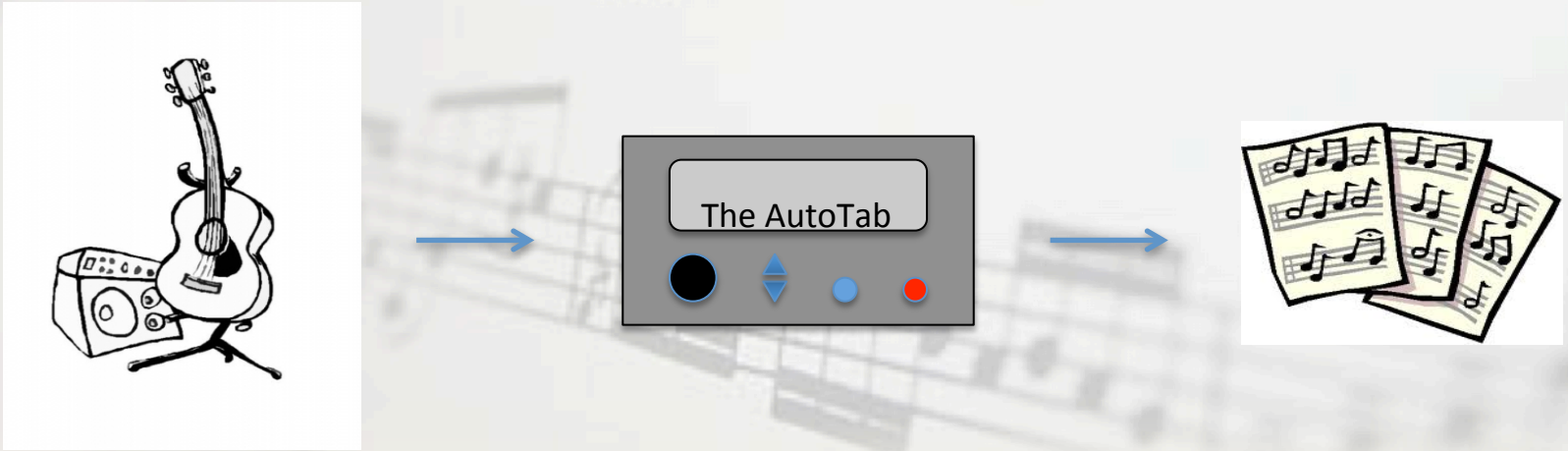
Introduction

- The AutoTab simplifies the music creation process
- All-in-one device that is not just a music transcriber, but also a metronome and a recorder.
- Easy to use and hassle-free



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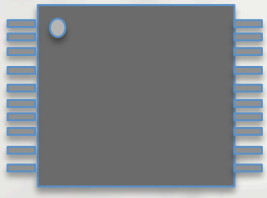
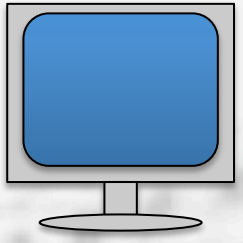
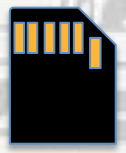
System Overview

Altera Cyclone IV (Terasic)





Sibelius 7



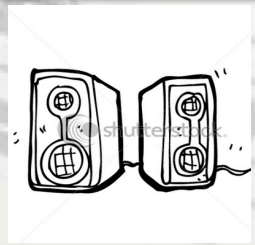
Signal Acquisition and Processing

MIDI to Staff converter

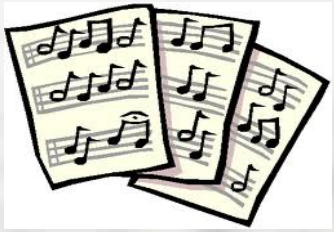
Memory

Audio Input

Audio Output



Written Staff



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Market Analysis

Target Markets:

- Musicians
  - Simplifies music creation process
- Education
  - Can be used as a tool to teach music theory
- Anyone and everyone!

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Market Analysis

Current Products:

- Tuner/Metronome
- Record/Playback Device
- WAV to MIDI Convertor Software
- MIDI to Written Staff Software

- Each task can be done separately but there is no all-in-one device on the market that performs all of the above

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Market Analysis

Proposed Solution: The AutoTab

- Simple: easy for general public to use
- Inexpensive: affordable for most people
- Portable: can be used in any environment or situation
- All-Inclusive: packages the tools needed by musicians into one device

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Budget

Equipment List	Estimated Unit Cost	Actual Unit Cost
Altera Cyclone II – DE2 University Dev Board (Terasic)	$269 – educational pricing	Sponsored
LCD Display	$50	-
Buttons and Caps	$12	$10
Switch	$2	$2
Batteries (5)	$10	-
microSD Card Socket	$4	-
16GB microSD	$30	Borrowed 2GB
Microphone	$5	-
Speakers	$5	-
LED	$5	-
Audio Jack	$2	-
Casing	$30	-
Total Cost	$424	$12

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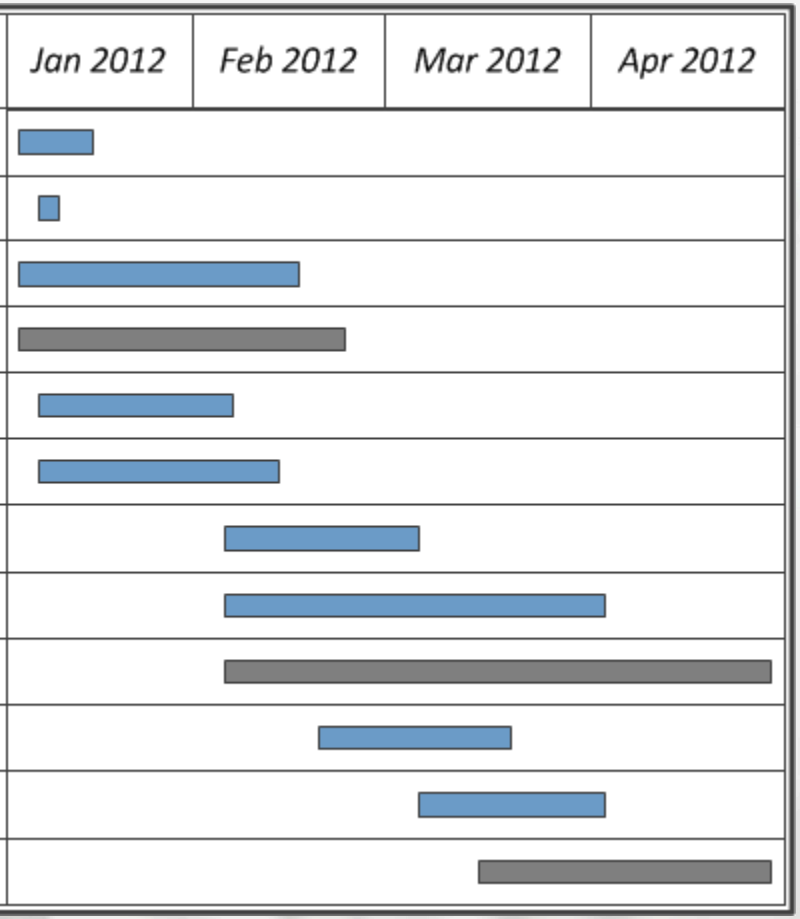
Timeline

ID	Task Name	Start	Finish
1	Project Proposal	1/6/2012	1/16/2012
2	ESSEF Proposal	1/9/2012	1/11/2012
3	Research	1/6/2012	2/16/2012
4	Research (Actual)	1/6/2012	2/23/2012
5	Functional Specification	1/9/2012	2/6/2012
6	Oral Progress Report	1/9/2012	2/13/2012
7	Design Specification	2/6/2012	3/5/2012
8	Coding/Testing	2/6/2012	4/2/2012
9	Coding/Testing (Actual)	2/6/2012	4/27/2012
10	Written Progress Report	2/20/2012	3/19/2012
11	Integration/Debugging	3/6/2012	4/2/2012
12	Integration/Debugging (Actual)	3/15/2012	4/27/2012



Cyclone IV and the DE2-115

- Terasic donated a DE2-115 development board
- Includes:
  - Cyclone IV E
  - Wolfson Audio Codec with Line-in/out
  - SD Card Port
  - Push Buttons
  - LCD 16x2 Module
  - 7-Segment Display
  - 17 Red and 8 Green LEDs
  - 128 MB SDRAM, 1 MB SRAM
- Project utilizes:
  - 18,676 / 114,480 (16 %) Logic Elements
  - 1,556,080 / 3,981,312 (39 %) Memory Bits
  - 99 / 532 (19 %) Embedded Multipliers

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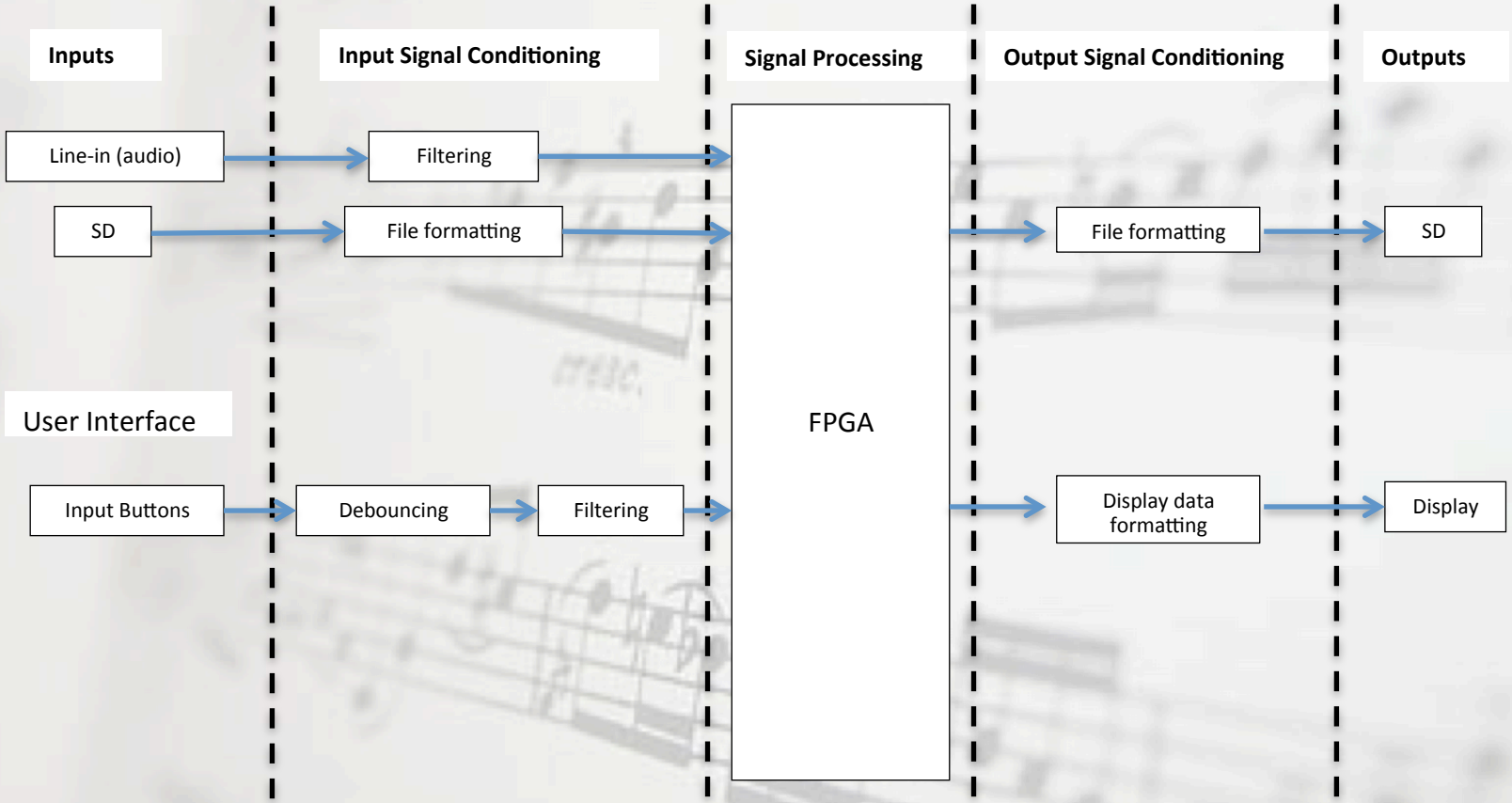
High Level System Design



Nios II Soft Processor

- Altera's soft processor core
- Implemented on the FPGA
- Nios II/f variant
- Instantiated floating point unit
- System clocked at 125MHz
- IOs clocked at 40MHz
- Audio core clocked at 18.42MHz

Fast Fourier Transform Core

- Part of Altera's Megacore IP library
- Implemented on the FPGA
  - Designed hardware wrapper to facilitate communication with CPU
- 16 bit data input, 32 bit output
  - Fixed point
- FFT length is 8192
  - With our down sampling algorithm: ~0.5Hz/bin
- Performance:
  - Load + Process + Unload = 3*8192 cycles = 24576 cycles

Musical Theory

Monophonic	Describes music consisting of single notes or a single melodic line
Polyphonic	Describes music with multiple melodic lines or multiple notes played simultaneously such as chords
Note	Musical notation indicating a particular pitch to be held for an amount of time
Fundamental	The lowest frequency signal present in a given musical note
Harmonic	Any whole number multiple of the fundamental frequency present in a note

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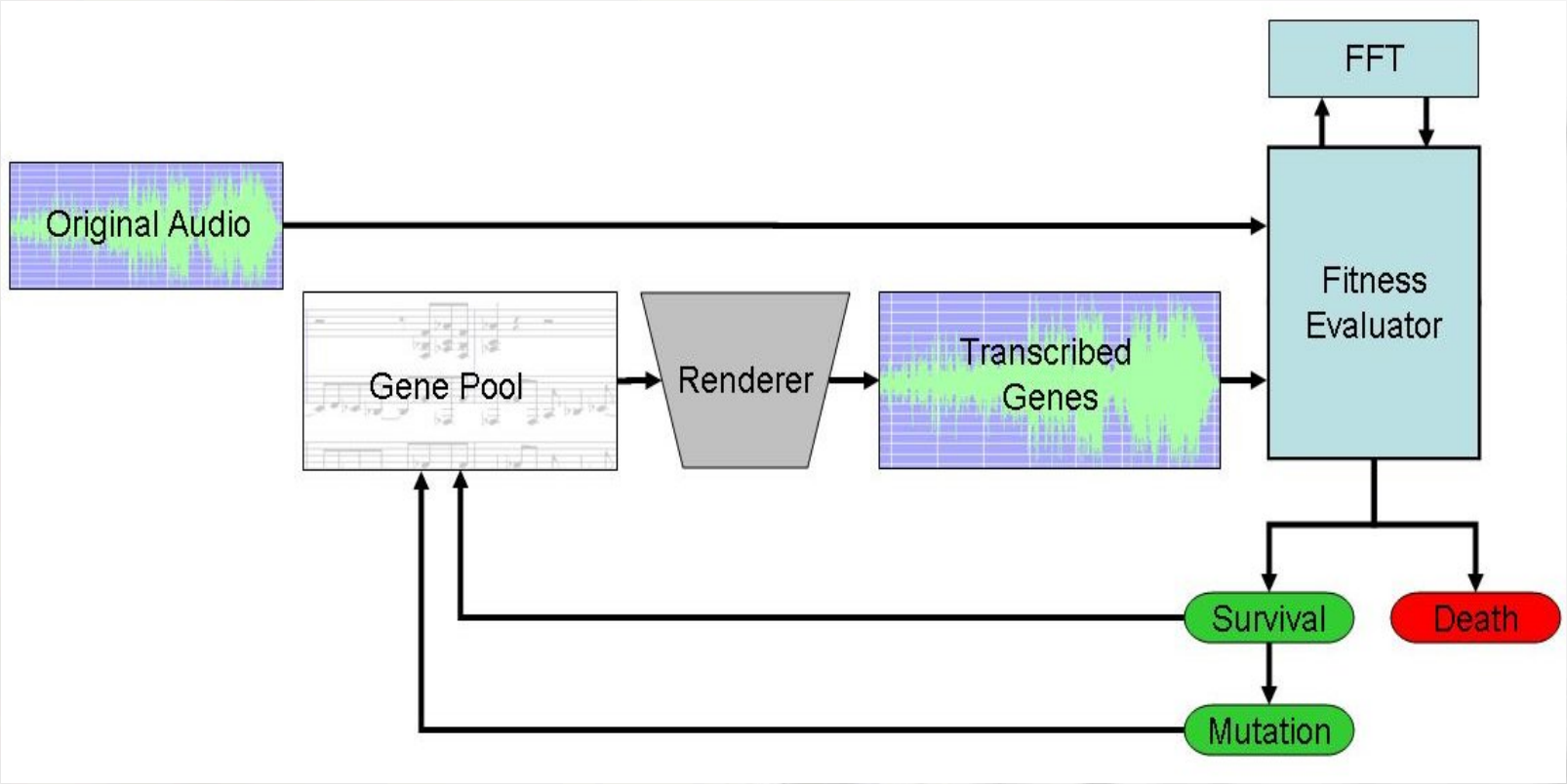
Algorithm Overview



Algorithm Flow

- Quantization
- Peak Extraction
- Fitness Evaluator
- Scaling Factor (worst fitness)
- Mutation Function
- Note Extraction
- MIDI Generator

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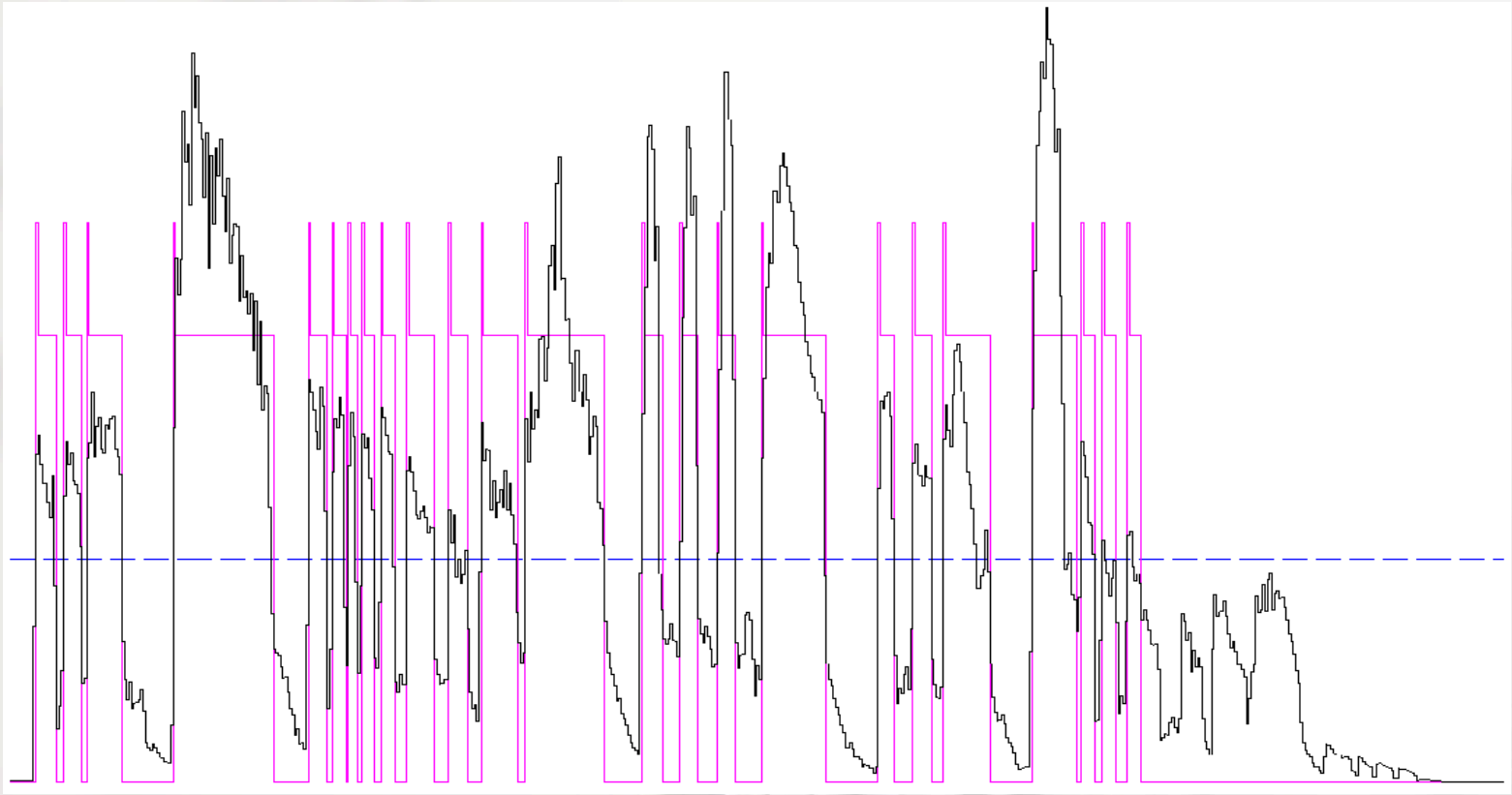
Quantization



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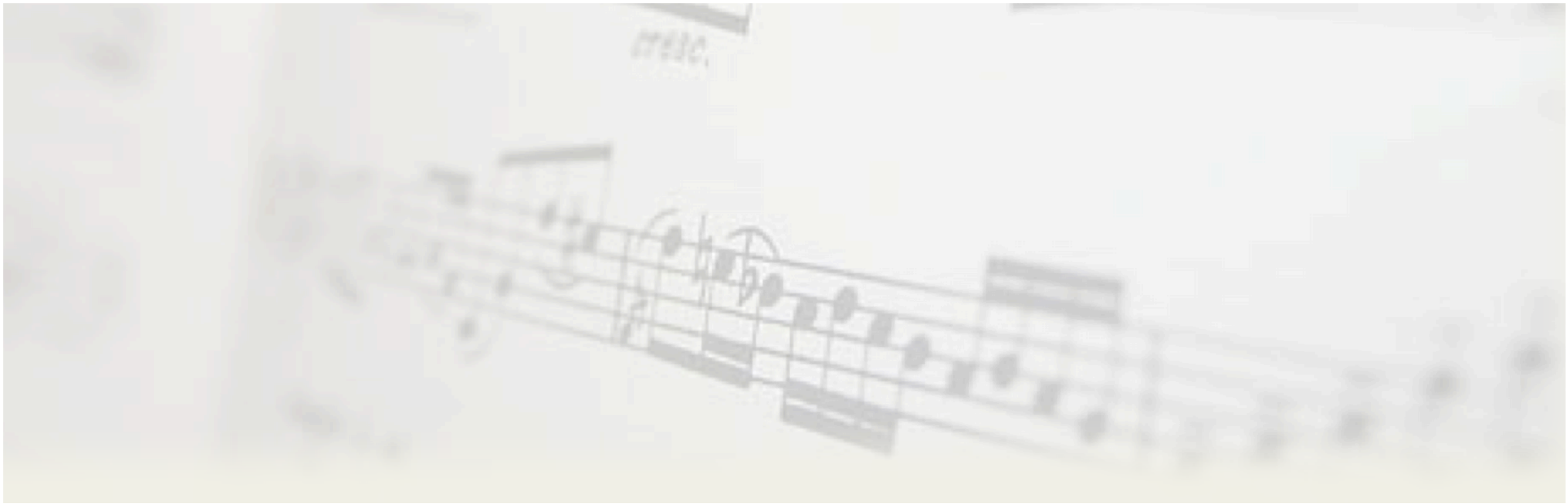
Fitness Function

$$Fitness = 1 - \frac{\sum_{t=0}^{tmax} \sum_{f=fmin}^{fmax} \left(O(t,f) - X(t,f)\right)^2}{\sigma}$$



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Lessons Learnt

- Research must be done thoroughly
- Ask for help and advice when you need it
- Perfection is inefficient
- Communication is critical

Future Development

- Portability
  - Implement device on an ASIC
  - Battery usage in place of a power supply
- Algorithm Refinement
  - Allow for multi-instrument transcriptions
  - Tuner implementation
  - Chord recognition
- User Interface
  - Implement menu options

Conclusion

- ScibeWare's AutoTab prototype successfully created
  - Has future potential (low cost + high effectiveness)
  - Fills a niche in the market
- Valuable experiences
  - Technical
  - Soft skills

Acknowledgements

- Dr. Andrew Rawicz
- Steve Whitmore
- Ali Ostadfar, Lukas-Karim Merhi and Shaghayegh Hosseinpour
- Lakshman One
- Terasic


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Questions?