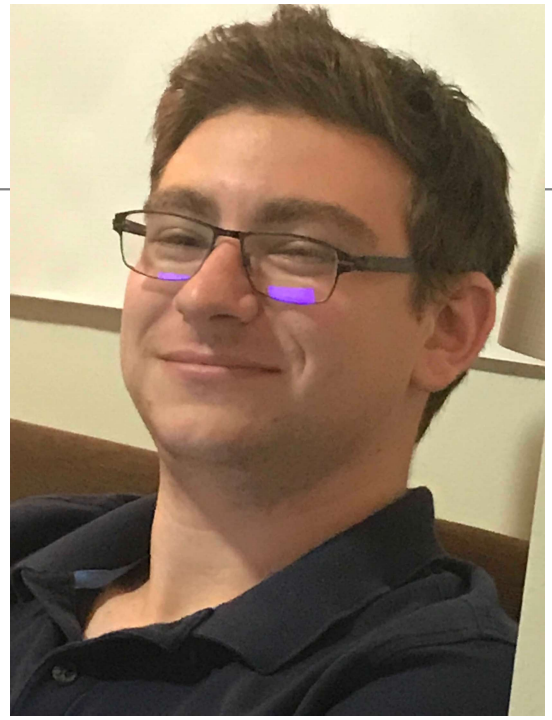
The BopBot

TEAM 21

Meet the team

Matthew Cierpial
CSE



Max Jaffe
EE

Austin Reilly
CSE

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CSE

Advisor: Prof. Moritz

Some Common Music Terms

Key- a group of notes, or scale, that forms the basis of a musi

Chord- a group of multiple notes played at the same time

Chord Progression- a succession of chords which typically can
the key.

Melody- a linear succession of notes that the listener perceive
entity.

Measure- A segment of time corresponding to a specific num
which is defined by a type of note.

Time Signature- A notation to convey how many beats are co
measure(ex. 4/4 is four (numerator) quarter (denominator) n
measure)

Beats per minute (BPM)- A way to determine the tempo of a
The type of note defined in the time signature is 1 beat(ex. in
there are 120 quarter notes in a minute)

Do you recognize thi song?

How about now?

The Importance of the Melody

- Some of the most popular songs follow a I, V, vi, IV c progression
  - Train - “Hey, Soul Sister”
  - Jason Mraz – "I'm Yours"
  - James Blunt – "You're Beautiful"
  - The Beatles – "Let It Be"
  - Bob Marley – "No Woman No Cry"
- A melody (typically, vocal) is what makes a song interesting and unique

Problem Statement

The most memorable songs often feature a compelling (vocal) melody. Musicians often struggle to write melodies that are catchy and unique. T BopBot can inspire this creative process by offering melodies based on w you play into the machine. After defining timing parameters, the user w prompted to play a chord progression. The BopBot will then generate a cohesive and interesting sequence of notes using its recurrent neural ne The user can then playback the chord progression and melody together inspire different musical motifs to use in their own melodies.

The Two Main Uses of the BopBot

1. As a creative-assistance tool
2. Jammin’ with your friends

System specifications

1. Uses machine learning to generate melody
2. Digital screen for user inputs of beats per minute
3. Several genres available with different models
4. Will count the user in at their desired timing parameters with a metronome
5. Can fit into a foot pedal board
6. Powered by either a 9V battery or musician's daisy chain
7. Live recording and playback with short music generation process
8. Must be able to handle chords as input and playback those chords
9. User input can be any chord progression
10. Playback with desired timing

Current tech: AIVA

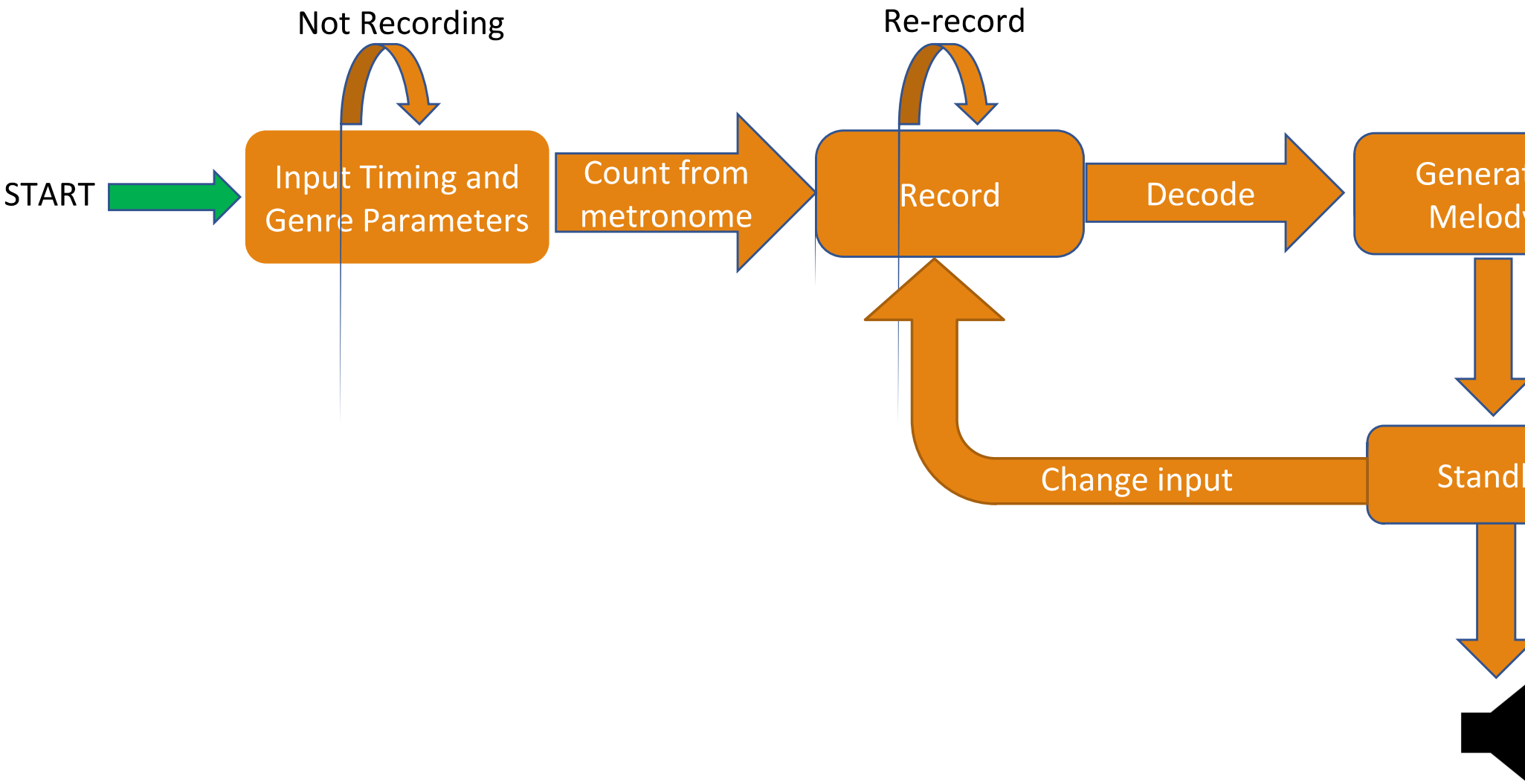
This system does not meet:

Specification 5: Can fit into a foot pedal board

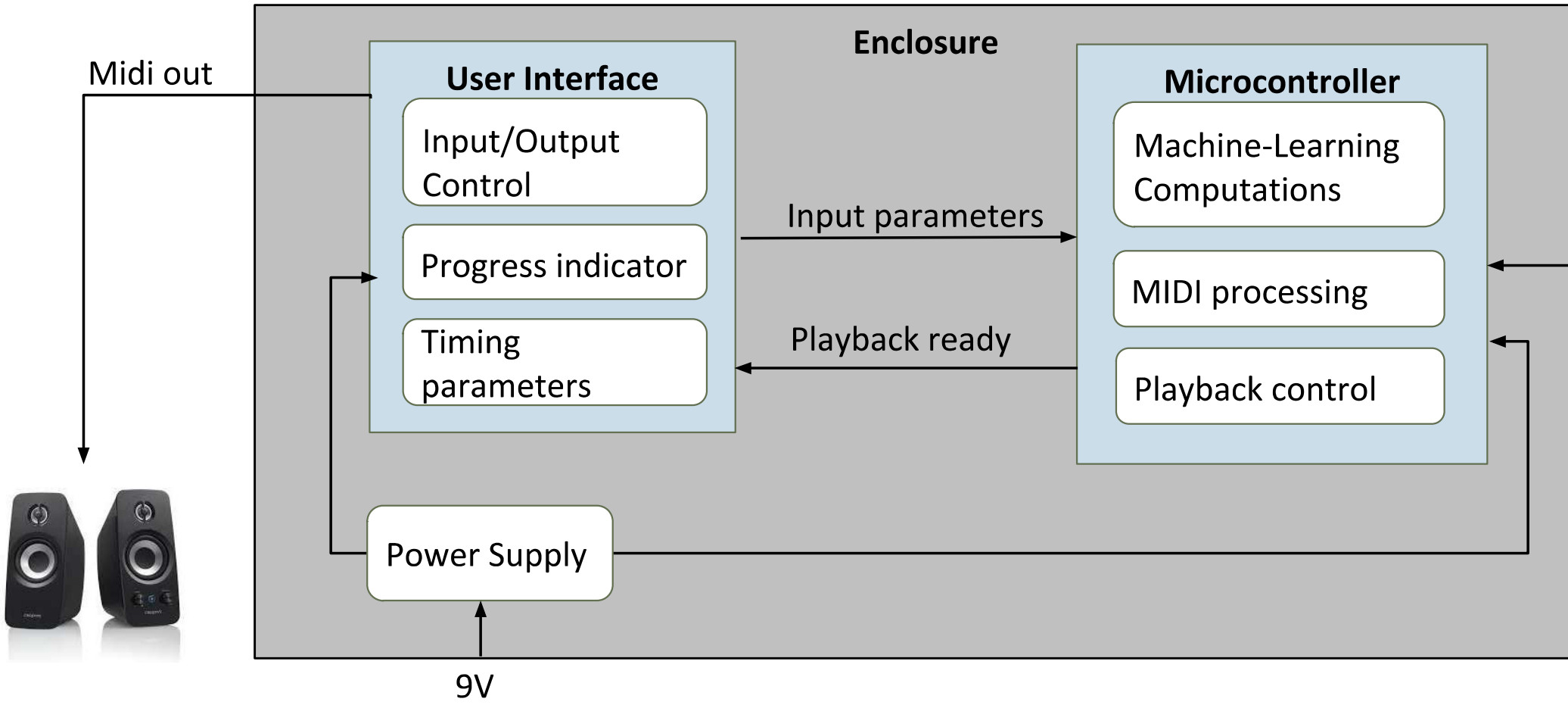
Specification 6: Powered by either a 9V battery or musician's daisy chain

Specification 7: **Live** recording and playback after short music generation process

Flow Diagram



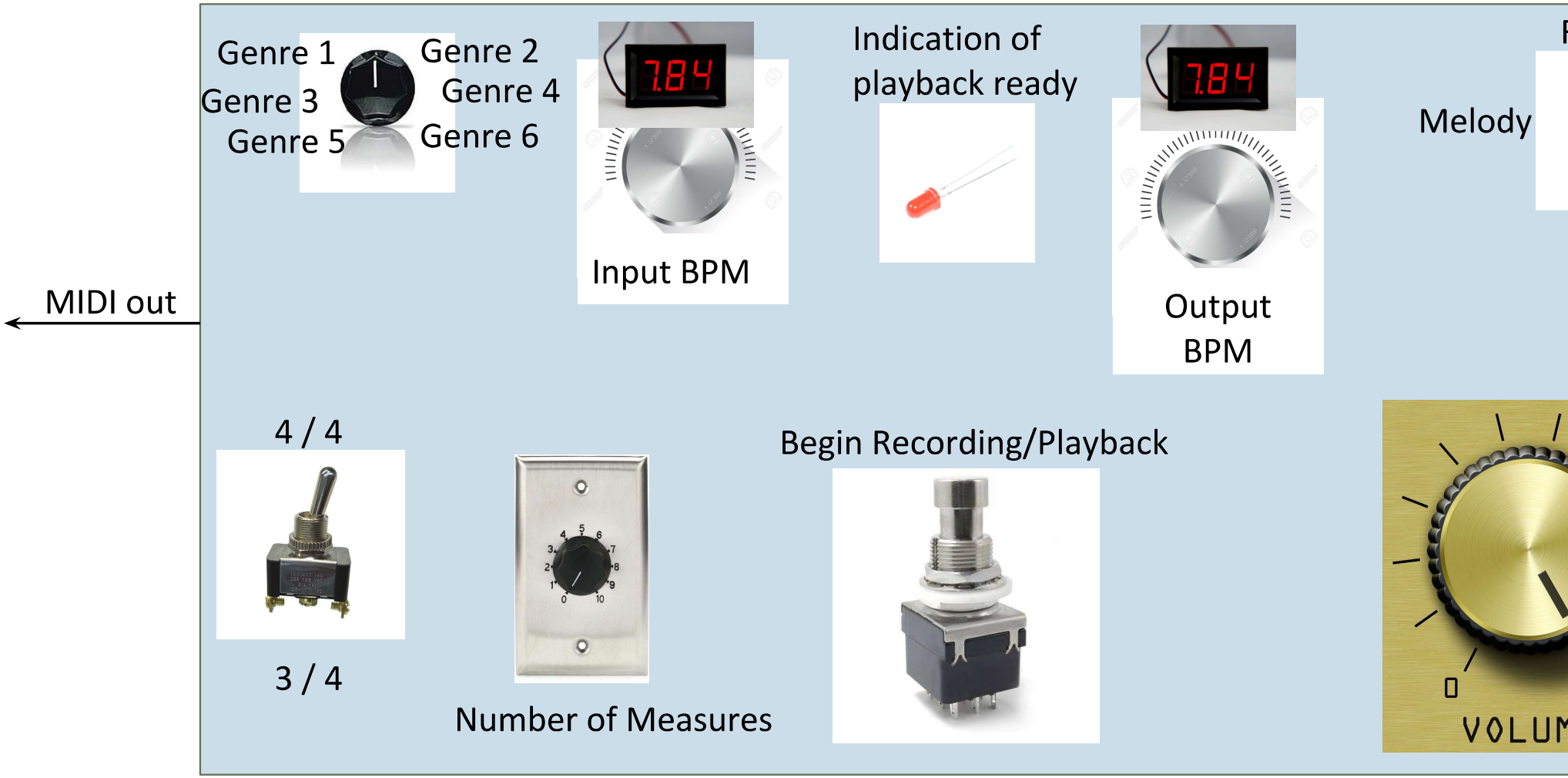
Block diagram



Subsystem (Enclosure)

- Musicians often use pedals, sometimes called stompboxes
- A comfortable foot-pedal that requires decent amount of force to activate
- Sturdy case that can take wear and travel and being stepped

Subsystem (User Interface)

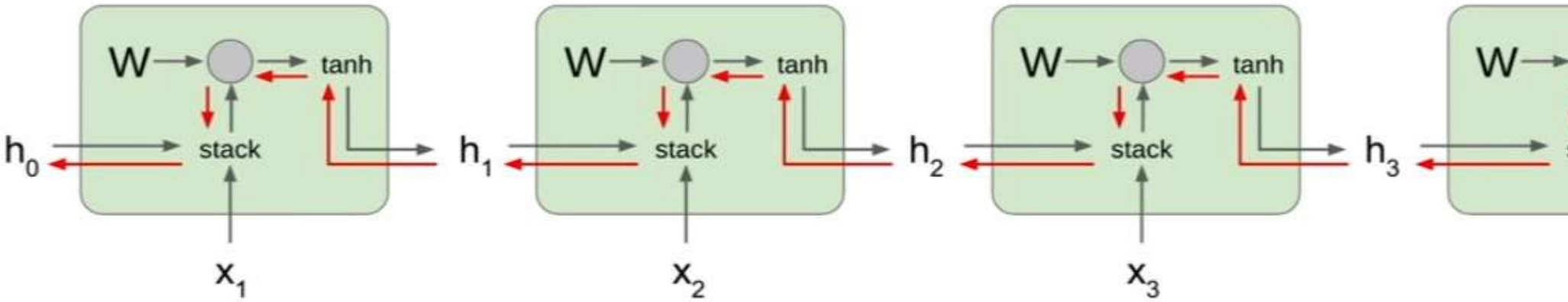


Subsystem (Microcontroller)

- Runs main C program which will control functionality of the boards peripherals, and MIDI input processing
- Responsible for computing machine-learning generated melody
- Responsible for playback control

Vanilla RNN Gradient Flow

Bengio et al, "Learning long-term dep
is difficult", IEEE Transactions on Neu
Pascanu et al, "On the difficulty of trai
ICML 2013



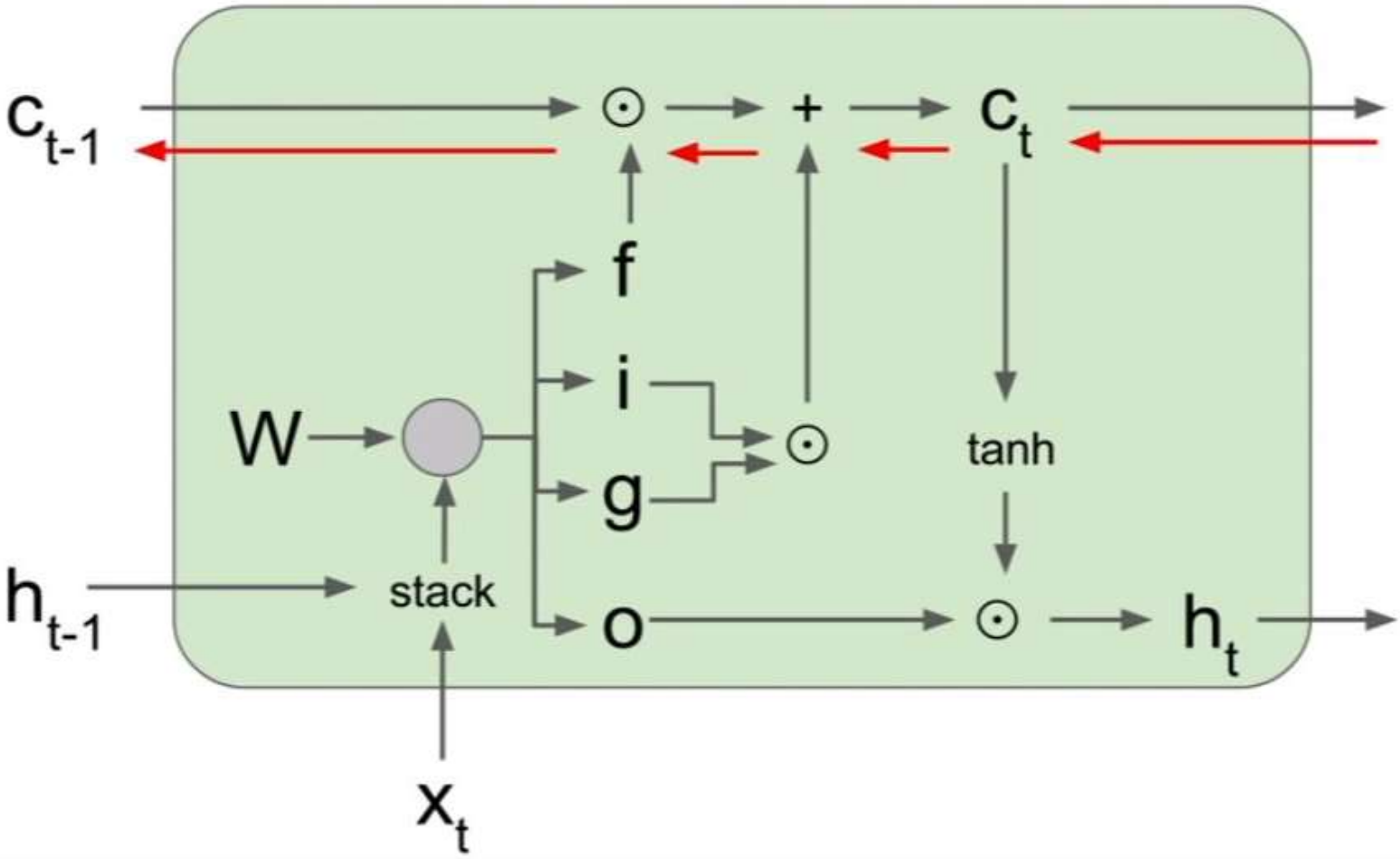
Computing gradient of h_0 involves many factors of W (and repeated tanh)

Largest singular value > 1:
Exploding gradients

Largest singular value < 1:
Vanishing gradients

Long Short Term Memory (LSTM): Gradient Flow

[Hochreiter et al., 1997]



Backpropagati

c_{t-1} only eleme

multiplication b

multiply by W

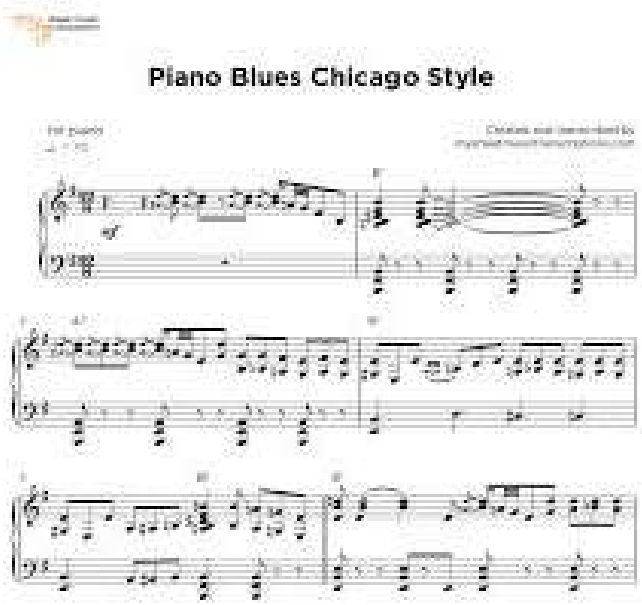
$$\begin{pmatrix} i \\ f \\ o \\ g \end{pmatrix} = \begin{pmatrix} \sigma \\ \sigma \\ \sigma \\ \tan \end{pmatrix}$$

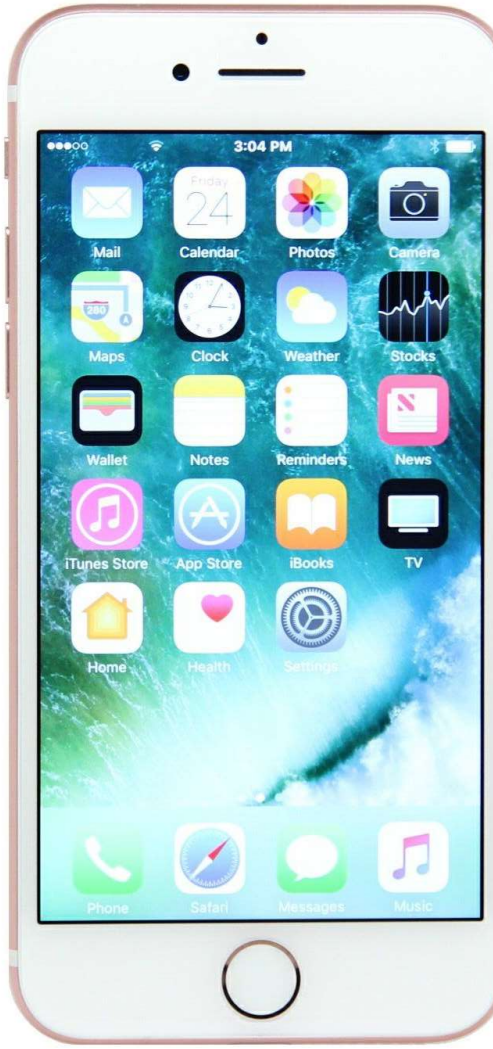
$$c_t = f \odot c$$

$$h_t = o \odot t$$

Possible Features

- Sheet Music Printing
- Phone app to save and edit melodies
- “Jam Mode”





Risks

Machine learning risks

- Output is over-averaged and therefore bland (Mode Collaps
- Output is not satisfactory in its proximity to human-made me

Hardware risks

- Enclosure will not survive wea tear

Why not just use a computer?

- Cheaper
- Easier to setup and use live
- Doesn't fit target demographic (musicians)

Team roles

Software

- Vee: Machine Learning
- Matt: Playback

Hardware

- Austin: Embedded programming & PCB layout
- Max (Project Manager): Enclosure and UI design & PCB layout

Everyone will be working on data collection for model trainin

MDR deliverables

Live recording, melody generation playback

More than one available genre mo choose from

Input will be in a specific key

Playback with correct timing

Budget

We expect to be very under budget!

- ~~Prototype Development Kit- De1-SoC~~ $0
- Microcontroller/ Memory Chip $20-40
- PCB print $15
- Miscellaneous hardware (switches, LEDs, cables, etc.) $30-50
- Enclosure $15
- ~~Electric Keyboard~~ $0
- ~~Speakers~~ + $0

$120 (max.)

Questions?