MIDI Autofill

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Contents

1 Executive Summary

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2 Project Overview

2.1 Technical Objectives

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2.2 Goals

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2.3 Legal, Ethical, and Privacy Issues

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2.4 Broader Impacts

3 Broader Impacts

One of the most difficult aspects of producing music as a hobby is a lack of accessible equipment. Often, it requires several pieces of hardware at over $100 each as well as licensed software to compose a polished track. This expensive and convoluted process restricts the reach of music production as an art. As technology expands into the music production world, the art becomes more accessible to the everyday person, and the MIDI Autofill keyboard will be yet another step along that path. With recording, editing, and auto-completion all conveniently packaged into a single portable piece of equipment, novice producers can begin completing polished tracks without having to seek out, invest in, and store a stockpile of hardware.

Additionally, the autofill feature can benefit new practitioners and professionals alike. One of the biggest stressors in songwriting is writer's block – it can completely bottleneck the production process and halt all progress until resolved. For beginners this can be frustrating and discourage further exploration into the art, and for professionals this can come at the detriment of deadlines. The melody autofill feature can provide inspiration or even an immediate solution, expediting the process and allowing artists to be more productive with their ideas. The goal is to

empower independent creators because the more people can express themselves through art, the richer and more diverse our culture and society become.

4 Specifications and Requirements

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5 Research

5.1 AI

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5.1.1 PixelCNN

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5.1.2 Magenta

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5.2 Embedded Controller Comparisons

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5.3 DAW Frontend Technologies

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5.4 Raspberry Pi

As mentioned in Embedded Controller Comparisons, the Raspberry Pi is mini-computer which can also function as an embedded controller. The model we're interested in is the Raspberry Pi 4B. This Raspberry Pi model uses the ARM64 architecture. It can run numerous ARM64 based Linux distros. The advantage here is the software and tooling that is available for us to run in a Linux environment. After an analysis of other solutions, we have decided that the Raspberry Pi is the best fit for our project. To that end, we have researched how the Raspberry Pi can be configured for use in our project.

5.4.1 Operating System Choice

The first configuration choice that needs to be made is the operating system. A Raspberry Pi out of the box has no operating system. An image must be flashed to an SD card to make the Raspberry Pi useful. Raspberry Pi's typically run some form of Linux. There are a number of choices available, as there are many flavors of Linux that can run on the ARM64 architecture. Some common choices for Raspberry Pi include Raspberry Pi OS (formerly known as Raspian), Arch Linux ARM, and DietPi. Each OS has its advantages and drawbacks, and it is important for us to select a distro that is well suited for our use case.

The most common operating system used for Raspberry Pi is Raspberry Pi OS. This is a specially tailored version of Debian for the Raspberry Pi. This is a common choice for any general purpose usage the Pi. It can be used like a normal desktop computer when a mouse, keyboard, and monitor are plugged in. This is a ”batteries included” distro that includes many things we will never use. The bloatware from this distro can hinder performance and waste SD card space. There is a lightweight alternative known as Raspberry Pi OS Lite. This version does not include any desktop environment.

DietPi is similar to Raspberry Pi OS Lite in that it aims to be a lightweight distro. DietPi's website claims to be even lighter than Raspberry Pi Os Lite. It occupies 589 Mb on the SD card, while Raspberry Pi OS occupies 1424 MB. There are a

number of other system optimizations in place to improve general performance. After boot, there are only 11 total processes, versus 18 total processes running on Raspberry Pi OS.

There are also specialized distros that are only meant to do one specific thing. Examples include RetroPIE, which is used to run retro video games, or OpenMediaVault, which is used to turn the device into a networked storage device. This is similar to what we want our operating system to do. Our use case for the Raspberry Pi is to run one specialized application that we ourselves develop. It should boot straight into our application with no other UI from the operating system. The best solution for us is to have a custom distro just for running our application. Developing a Linux distro from scratch is a difficult process that is out of the scope of this project. But what we can do is modify an existing distro to suite our needs.

5.4.2 Operating System Configuration

The operating system will need to be configured for our use-case. We need to get the operating system to boot a single GUI application, our DAW, without displaying any other UI from the desktop environment (DE). There may be more applications separate from the DAW that will run in the background which also must be started immediately after boot. The operating system will need to be configured to not permit any networking out of security and privacy concerns.

To only display a single application, we need to configure the graphics system in our distro. Graphics in Linux are done through the X Window System. In modern apps, X is mostly agnostic to the UI, and is used for providing UI toolkits a method for accessing bitmaps to windows. X can be configured in a variety of ways. The way we intend to configure X is to host a single fullscreen application for our DAW. This can be done through the `.xinitrc` file. This file specifies which commands to run whenever the X server is started. By simply including the command to run our application in there, we will have a single window at startup.

Networking can disabled through the `/etc/network/interfaces` config file. This config file is used to declare all networking interfaces, and the interfaces can be removed by simply removing all lines declaring a networking interface in that file.

5.4.3 Packer

A solution we found for customizing an existing Linux distro is Packer. Packer is a utility that can take an existing operating system image, modify it, and produce a new image. Modification is done through provisioners, which exist to perform steps, such as copying files, running shell commands, setting permissions, etc.

Packer relies on builders to carry out the tasks laid out in a configuration file. The builder we will use is called packer-builder-arm, which builds ARM images and is suitable for a Raspberry Pi.

We can use our own Packer config file to setup all the tasks described in Operating System Configuration. For example, we can use the file provisioner to copy the `.xinitrc` file to the home directory, which is used to configure X11 for our application.

5.4.4 Performance

Performance is always a concern when dealing with constrained embedded hardware. The Raspberry Pi fares better than microcontrollers you would find in a typical MIDI controller, but is still performance constrained. Our device needs to be able to run a machine learning model and a UI application, both of which are computationally expensive tasks.

Magenta Although we may not end up using Magenta, it serves as a good baseline for measuring performance of music generating AI. Magenta ships with two machine learning models: MusicRNN and MusicVAE.

5.5 Keyboard Design

6 Design Summary

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7 Implementation

7.1 Build plan

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7.2 Prototyping

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7.3 Testing

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7.4 Evaluation

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8 Equipment

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9 Budget

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10 Milestones

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11 Division of Labor

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12 Project Summary

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13 Conclusions

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