DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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ApolloTrax: An AI Music Generation App

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1. Project Definition

a. Background

Since the invention of the iPod, many people have had access to music in many different and remote settings. The introduction of the internet along with various music streaming services such as Spotify has expanded the user's choice of music which often makes it difficult to decide what to stream that is in line with a person's surroundings, personal needs, or mood. Currently, there are a plethora of music apps across both Android and Apple platforms which offer state of the art functionality in terms of streaming music from various sources. Among these music streaming apps, there are an increasing, although less prevalent, number of apps which claim to detect a person's mood. With the introduction of the AI Music Controller which we have named ApolloTrax, our aim is to seamlessly blend artificial intelligence technologies along with machine learning and mood detection algorithms to provide state of the art music selection to suit mood and surroundings.

b. Objectives

Many studies have shown that music can be an uplifting experience, often allowing us to improve mood, outlook, and stress levels as well as reflect upon our future goals. The World

Health Organization (WHO) has defined positive mental health as “a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community” [1]. Additionally, The Journal of Positive Psychology conducted a study in 2013 which discovered that an individual's choice of music could significantly improve their mood and overall happiness in just a few weeks [2]. In line with the goals to achieve positive mental health through music, our app sets out to achieve the following goals: Personalize music selection based on individual mood or surroundings, enhance mood-based music selection via machine learning and data mining techniques, introduce user feedback into the selection process to personalize each user’s experience, and to promote positive mental health and stress management through positive coping strategies via auto selection of music choices.

c. Specifications and Constraints

- It must be compatible with other music apps on Android and iPhone (Spotify, Apple Music, Pandora, etc.)
- Login and access to personal account
- Work with Internet and/or Cellular Data
- Can run when the app is not open
- Options to like/dislike songs when they change to improve algorithm
- Should be able to access location data for algorithm-for example, if the user only plays high energy music at the gym the app can suggest the music of that genre when the user is in that location
- Either offer a subscription to make up for development costs or offer a premium version of the app where there are more features available
- Must be able to integrate with Apple Watch and FitBit to match music with physical activity
- Must be able to integrate with Siri and other speech recognition features on mobile devices

2. Methodology

a. Feasibility Analysis

The demand levels for music streaming worldwide shows continued growth, as seen in Figure 3 which is a graph taken from a study done by Airnow in February of 2022. With the Google Play store music streaming downloads for Spotify alone being in the 10 millions, our group sees this as an appropriate market to develop an application for. In connection with this, the wellness industry is well entrenched from a body and fitness perspective and is often intertwined with mental wellness. Part of this mental wellness push is the continuous growth and desire for “mood” based apps. These mood-based apps suggest workouts or meditation routines for people depending on the mood they are experiencing and allow them to log their emotions on

the app and tailor the app experience to their mood. Figure 4 shows a Google Trends study that tracks the number of searches for “mood apps” over the past 10 years, with the study ending in 2019. This figure shows an obvious increase in the desire to have a mood application for users. Our group, seeing that the trends for both music streaming apps and mood-based apps are positive, want to combine these two ideas and create a mood-based music streaming app. There are very few mood based music apps available on the market and ApolloTrax would fill a need for consumers everywhere.

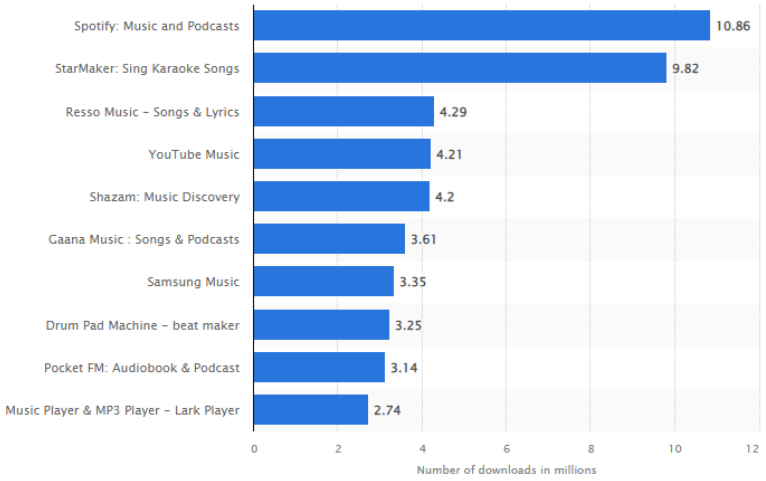


Figure [3]

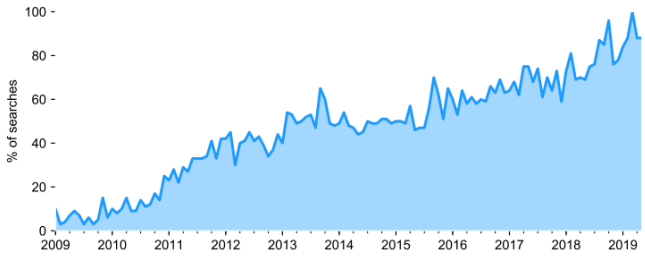


Figure 1. Number of searches of “mood app” during the last 10 years. Values expressed in percentage relative to the total amount of searches on that topic. Source: Google Trends [17].

Figure [4]

b. Proposed Approach

The approach that the group intends to take is to develop an algorithm that breaks down songs into quantifiable musical components such as rhythm, harmony, or timber. The group will then research into music theory and analyze each track’s audio features such as BPM, key, valence, chord, progression, etc. from Spotify and Apple Music API. Using this information, as well as the studies below which associate these factors with human emotion, the group will develop an algorithm that can place songs into categories such as happy, sad, energetic, calm, etc. Once this algorithm is written, the next step will be to integrate this with user interaction to

play music that fits a person's selected mood within the application. The app will be able to track the user's location and pick up on patterns such as playing relaxing music when the user is home or playing fast BPM music when the user appears to be at the gym. The user has the option to like or dislike the song that is suggested, which allows the user to listen to music that fits their mood in a genre that they prefer. The user will also be able to use the Siri features on both AppleWatch and iPhone to search for songs either by mood or by lyrics. The application will also be able to display the moods that the user's music fits into most often after a certain amount of streaming activity on the application.

Mode	Tempo (beats per minute)		
	72	108	184
Musicians			
Lydian	Sadness (56.7%)*	Serenity (63.3%)	Happiness (90%)
Ionian	Serenity (63.3%)	Happiness (50%)	Happpiness (96.7%)
Mixolydian	Sadness (53.3%)*	Serenity (66.7%)	Happiness (80%)
Dorian	Sadness (56.7%)	Serenity (60%)	Happiness (73.3%)*
Aeolian	Sadness (53.3%)*	Serenity (46.7%)*	Happiness (53.3%)*
Phrygian	Sadness (70%)	(Serenity 33.3%; Sadness 33.3%; Fear/anger 30%)	(Happines 43.3%; Fear/anger 40%)*
Locrian	Sadness (60%)*	(Serenity 33.3%; Sadness 33.3%)*	Fear/anger (50%)
Nonmusicians			
Lydian	Serenity (63.3%)*	Serenity (56.7%)	Happiness (80%)
Ionian	Serenity (70%)	Happiness (66.7%)	Happpiness (100%)
Mixolydian	Serenity (70%)*	Serenity (50%)	Happiness (83.3%)
Dorian	Sadness (66.7%)	Serenity (50%)	Happiness (43.3%)*
Aeolian	Sadness (83.3%)*	Sadness (60%)*	(Happiness 43.4%; Fear/anger 40%)*
Phrygian	Sadness (63.3%)	(Serenity 33.3%; Sadness 33.3%)	Fear/anger (40%)
Locrian	Fear/anger (56.7%)*	Fear/anger (56.7%)*	Fear/anger (60%)

Data are reported as percent (mean). Pieces that were not associated with a dominant emotion are given in parentheses. *P ≤ 0.005 compared to musicians' or nonmusicians' responses (ANOVA).

Tempo Research [5]

Mood	Intensity	Timbre	Pitch	Rhythm
Happy	Medium	Medium	Very High	Very High
Exuberant	High	Medium	High	High
Energetic	Very High	Medium	Medium	High
Frantic	High	Very High	Low	Very High
Anxious/Sad	Medium	Very Low	Very Low	Low
Depression	Low	Low	Low	Low
Calm	Very Low	Very Low	Medium	Very Low
Contentment	Low	Low	High	Low

Advanced Classification [6]

Table 3: Chord types and their associated emotions [25].

Chord Type	Example	Associated Emotions
Major	C	Happiness, cheerfulness, confidence, satisfaction, brightness
Minor	Cm	Sadness, darkness, sullenness, apprehension, melancholy, depression, mystery
Seventh	C^7	Funkiness, moderate edginess, soulfulness
Major Seventh	C^{maj7}	Romance, softness, jazziness, serenity, exhilaration, tranquillity
Minor Seventh	Cm^7	Mellowness, moodiness, jazziness
Ninth	C^9	Openness, optimism
Diminished	Cdim	Fear, shock, spookiness, suspense
Suspended Fourth	C^{sus4}	Delightful tension
Seventh, Minor Ninth	$C^{7/9-}$	Creepiness, ominousness, fear, darkness
Added Ninth	C^{add9}	Steeliness, austerity

Chords and Emotions [7]

c. Non-technical Aspects

The non-technical aspects of this project mostly concern the application marketing and the gathering of data from potential users to determine what users would want in a mood-based music application. The marketing component of this project will require the use of advertisements, preferably on social media platforms such as TikTok or Instagram that state the basic functions of the application and focus on the personalization aspect of ApolloTrax. The research into the correlation between music and mood would also be a non-technical part of the project that is vital to our success as a mood-based music app. There are other studies done on this topic, but it may be worth it to conduct our own studies and read into more theories on how BPM and valence can affect the mood of a song. Lastly, once the app is created we would like to present it to potential users and ask for their feedback on the product. It will help us see if we are missing any key features that users desire, or if the app is good as is.

3. Administration

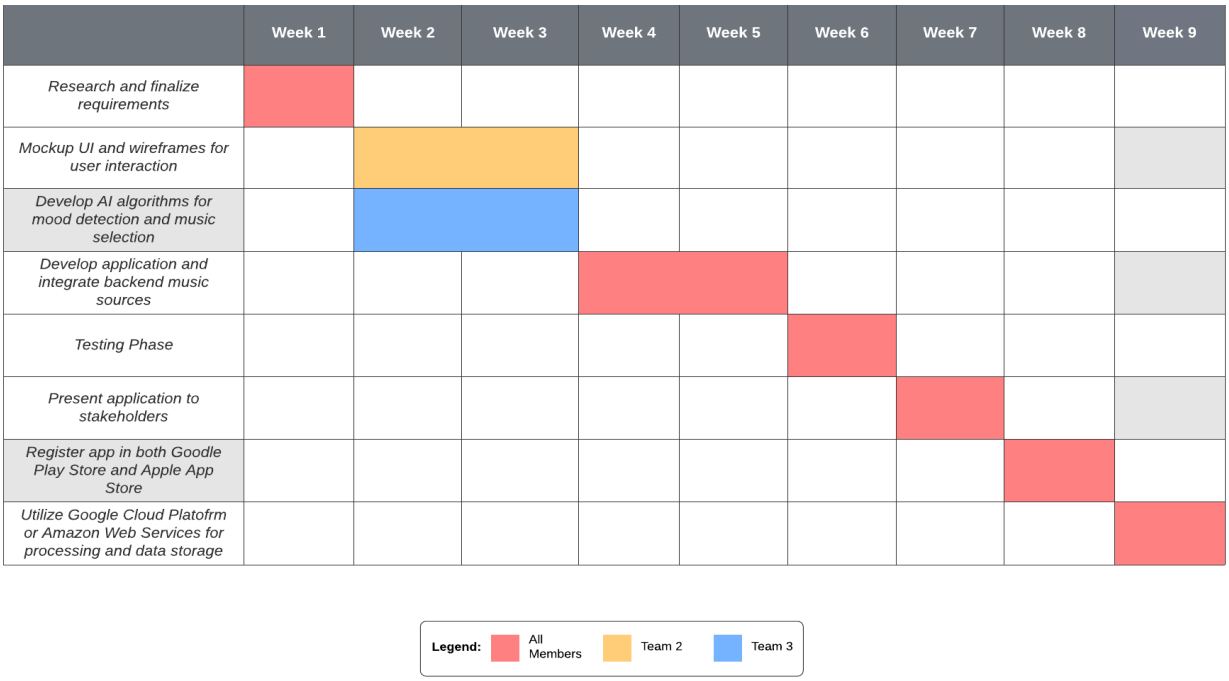
a. Major Tasks

The major tasks of this project are carried out based on the Agile development model, which has been widely proved to increase employee engagement and the quality level of software in organizations. The project team starts by collaboratively researching the market trends and finalizing necessary technologies requirements, then goes on to design the skeleton for the project by designing a mockup user interface and wireframes. Devising complex AI algorithms and integrating them with various backend music sources and devices such as but not limited to Apple Watch and FitBit are key components of making a functional app before the testing phase. Once all the tests are passed, we move to the pilot phase where we would select cross demographic users to gauge feedback and present our application to the potential stakeholders Our team will utilize a cloud-based platform such as Google Cloud Platform or

Amazon Web Services to control our application's source code as well as to process and store data. The application will be available on iOS and Android in their respective stores, App Stores and Google Play, and will be free to download.

b. Schedule

Below is a Gantt Chart breaking down task responsibility and the amount of time it will take to accomplish each major task as listed above. Assuming our team is using an agile development method, the team would have weekly meetings to update each other which are not included here. These meetings would be considered SCRUM meetings, hopefully a maximum of 15 minutes a day, to keep the team members updated on what has been accomplished. The red blocks on the schedule indicate all team members will be working on those tasks. The yellow and blue are two different teams: one would focus on the UI and wireframes while the other will focus on developing the AI algorithms. We split the members up into 2 teams so that we could complete the process of designing a bit more efficiently. Once these were created, most of our tasks would involve the integration of both parts as well as presenting to stakeholders, so we made all members a part of those tasks. This application will take approximately 9 weeks to complete, with hopes that we can launch the application at the end of the 9 week period. This is an optimistic schedule as there are always issues in the development process, but we hope to stick to this schedule.



c. Budget

Item	**Unit Cost**	**Total**
Labor Costs	$80/hr	$115,200 (9 weeks, assuming 9-5 work week and 4 group members)
App Development	$80,000	$80,000
Adding app to Apple App Store	$99.00	$99.00
Adding app to Google Play	$25.00	$25.00
UI/UX Design	$5,000	$5,000
Quality Assurance	$9,500	$9,500
Project Management	$10,000	$10,000
Total Cost		$219,824

Above is the budget that we allocated for the application development process. Stat We researched different budgets available on line that people have constructed for app development. In our research, we found that low level apps can take on average anywhere from 60,000-100,000 while more intricate apps would take anywhere from 140,000-250,000 to develop and deploy [8]. We assumed that our app would be intricate enough to require a larger budget, and we assumed that we would get this money through shareholders. As you can see our largest expense is for labor costs, which is the most important part of creating a product. We used research to see what average salaries per hour are for software developers in the United States to base our salaries on. We found that the average salary per hour for software developers was around $50, but we wanted to ensure that our employees were compensated for potential long hours and the short amount of time they would be paid [9]. There are one time fees for adding apps into the Apple App Store and the Google Play store which need to be accounted for. We have approximately $35,000 allocated for UI/UX design, project management, and quality assurance. In total, the application costs are expected to be $219,824 and the team hopes to make up for these costs by introducing a premium subscription feature in our application to give users more features.

d. Facilities and Resources

We develop partnerships with companies such as Spotify and Apple Music to gain access to their data on user music preferences to help determine appropriate music choice via the application. In order to build a secure and updated system, our other resources are IoT compatibility, which helps the AI determine appropriate music, a general purpose baseline serverwide AI system, a localized AI system to adapt on an individual basis and a HMM (Hidden Markov Model) speech recognition. For facilities, our minal requirements are to have computers for local development and a main office for a coworking space.

e. Personnel

We plan to have 4 main departments: Psychology, Engineering, Marketing and Management. The Psychology Department determines customer needs and provides information to improve AI capabilities. The Engineering Department executes main technical aspects of the project such as construct application and the AI. The Marketing Department finds potential customers and promotes their interests. The Management Department encourages collaboration between different departments and ensures that all specifications are met.

4. References

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