Guitar Simulator Based on Realtime Recording

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***Abstract*—Music is an art that combines several compositions of musical instruments. Among them are vocals, piano, guitar, bass, drums, and so on. To play a musical instrument also requires a technique to a formula, so that the music game becomes more harmonious. Techniques and formulas in playing musical instruments include tempo, rhythm, how to play a musical instrument, to chords. But for people who are just learning to play a musical instrument, it is certainly difficult to know the formula for the chords to be played. Not to mention when the sound of the chord being played is different from the sound of the intended chord. This can change a song being played sound fake or deviate from the actual song. Often in learning to play musical instruments, some media do not explain or explain how the chords are played and whether the chords are played correctly. One way to determine the accuracy of the chord sound in a self-taught music game, can be done using the help of Machine Learning. This method records the sound of guitar chords being played and classifies guitar chords according to their original sound. However, chords that can be classified are still limited to basic chords, because they are intended for the most basic learning. And for the display of the chord formula that is played it will be more interactive when using game design.**

***Keywords*—Chord Prediction, Guitar, Game, Machine Learning.**

I. INTRODUCTION

MUSIC is an art that combines several compositions of musical instruments that are played in a structured manner so as to produce a harmonious sound. Among them are vocals, piano, guitar, bass, drums, and so on. In playing a musical instrument, techniques and formulas are also needed, including how to play a musical instrument (drums are hit, bass & guitar plucked, piano is pressed, etc.), tempo or a measure of speed in the bars of a song, rhythm or arrangement of sound repetitions, and chords or a combination. harmonious tone.

For people who want to learn or are just learning to play musical instruments, especially guitars, of course it is necessary to know the formulas or formulas for each major and minor (C, D, E, F, G, A, B) major and minor chords. Starting from the position of the fingers in playing chords to the sound produced. The position of the finger will greatly determine the tone of voice that will be produced [1]. If there is one finger position that is not right then the sound produced will experience pitch deviation so that the song being played sounds discordant (false).

With advances in technology, various kinds of media have emerged for learning musical instruments. However, from several existing media, not all provide detailed learning including visual chord formulas and the accuracy of the sound of the chords being played. But with the help of technology too, a chord sound accuracy or accuracy can be determined using the help of Machine Learning [2]. With Machine Learning, a sound recording of a musical instrument can be classified into each appropriate chord, so that people who learn can know right or wrong on the chords being played. Chords that can be classified include the keys of C, D, Dm, E, Em, F, F#, G, A, Am, B. In addition, the following chords are a basic chord that is suitable for learning for beginners or lay people. For each chord type, there are 200 recorded chord sound datasets with different playing methods.

In terms of visual learning to understand the form of chord and rhythm formulas in the song game, it will be more interactive and easier to understand and follow when presented in the form of games. So that people who are learning can follow each rhythm arrangement and the correct finger position in playing chords in a song being played.

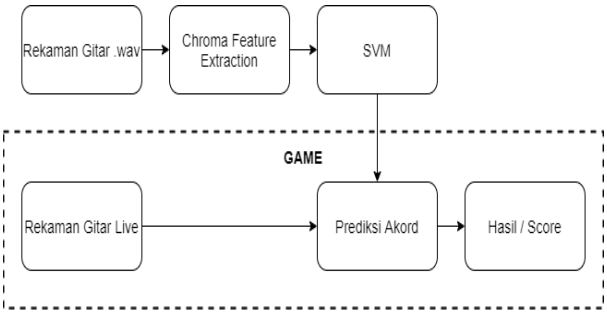

Figure 1. Block diagram of a general work system.

Table 1.
Number of records of each chord type

Chord	Quantity	Chord	Quantity
A	200	E	200
Am	200	Em	200
Bm	200	F	200
C	200	F#	200
D	200	G	200
Dm	200		

II. DESIGN AND IMPLEMENTATION

This final project applies Machine Learning science which aims to classify every guitar chord played with guitar chord recording pieces using the Support Vector Machine (SVM) method. The following Figure 1 is the flow of the design and implementation of this final project system in general.

III. DATASET

The method requires a dataset of each required chord type. Because this final project is aimed at beginners, the chords that are taken are only a few types of basic chords (C, D, Dm, E, Em, F, F#, G, A, Am, B). Guitar sound recordings are in the form of wav files on each type of chord, with an average duration of 3 seconds for each file. Each type of chord contains a different recording of how to play the guitar. Starting from strumming down, up, double strumming, and muted strum as in Table 1.

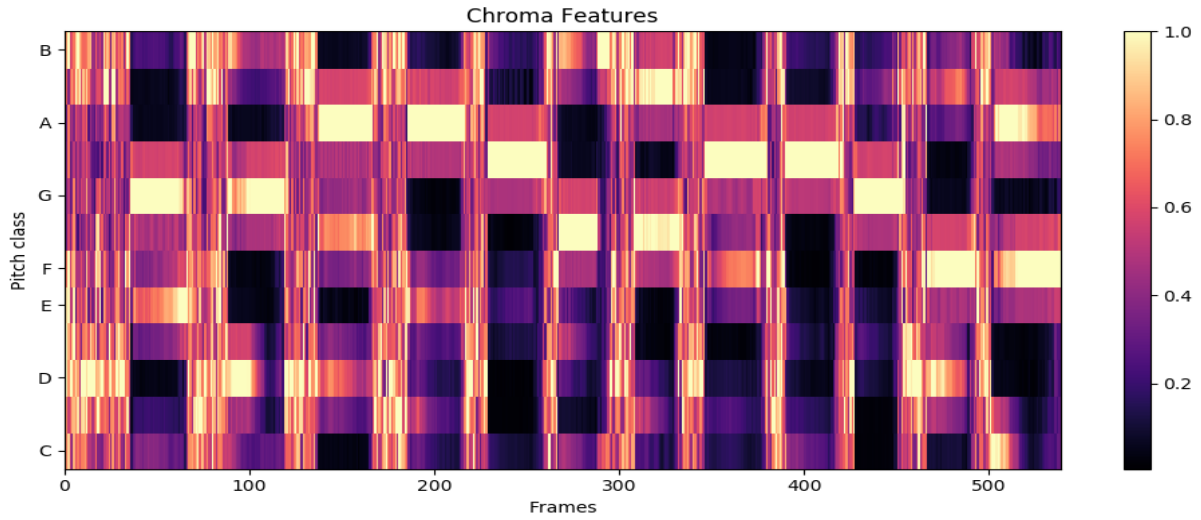

Figure 2. Chromagram of piano chords.

Table 2.
Testing with acoustic guitar

Music Chord	Testing Times	Correct	Incorrect (predicted)
Bm	20	20	0
F#	20	20	0
A	20	20	0
E	20	14	6 (Em)
G	20	20	0
D	20	17	3 (Dm)
Em	20	19	1 (E)
F#(2)	20	20	0

A. Chroma Extraction

Before the dataset is processed into machine learning methods, the wav recording is first extracted into 12 sinusoidal waves or what is called a Chromagram. Chroma Features is an attractive and powerful representation of music audio in which the entire spectrum is projected onto 12 bins representing 12 tones as Figure 2 differ from each octave of music.

This extraction is assisted by using a library from python called LibROSA. Once extracted, the collection of extractions is made into a csv (Comma Separated Values) file.

B. Support Vector Machine

The Support Vector Machine (SVM) method is a learning system that uses a hypothetical space in the form of linear functions in a feature that has high dimensions and is trained using a learning algorithm based on optimization theory [3]. This method is available in the python library called Scikit-Learn (SKLearn) and is available for other machine learning methods in this library.

The function of SVM in this study is used to classify labels using the best hyperplane by maximizing the distance between labels (chords), by separating one label from another. In Figure 3, the hyperplane is divided into 3, namely standard, positive, and negative hyperplanes. Positive means that all elements that are on or above (outside) are one class with label 1, and negative means that all elements that are on or below (inside) are one class with label 1.

C. Game Design

Building a game in a python program can use a library from python called PyGame. PyGame is an open source module developed by a community. This module is designed to be simple, easy to use, and fun. In addition, this research also uses a module from PyGanim to run an animation.

To make a game with this library, of course, you need designs for each game frame. This final project has a simple game design, therefore the design made consists of 2-dimensional frames or in the form of images. The required design is an image in png or jpg format. Figure 4 is the main design of the game and Figure 5 is the system (backend) of the game that will be made.

Before playing the game, a guitar is needed as input for the game. It can be an acoustic guitar (microphone) or an electric guitar (3.5mm jack cable). Once the guitar is connected to a computer or laptop, the player selects the song to learn the chords for. After the song is played, there will be a display of chords that match the song's playing. The player plays the guitar according to the displayed chords. The sound of the guitar being played is detected by the system and the chord sound is predicted. If the chords played or predicted match the chords of the song, the player gets a score of 100 and if it is wrong, he does not get a score. After the song stops, the game will end and show the last correct score obtained.

IV. TESTING AND ANALYSIS

Before playing the game, a guitar is needed as input for the game. It can be an acoustic guitar (microphone) or an electric guitar (3.5mm jack cable). Once the guitar is connected to a computer or laptop, the player selects the song to learn the chords for. After the song is played, there will be a display of chords that match the song's playing. The player plays the guitar according to the displayed chords. The sound of the

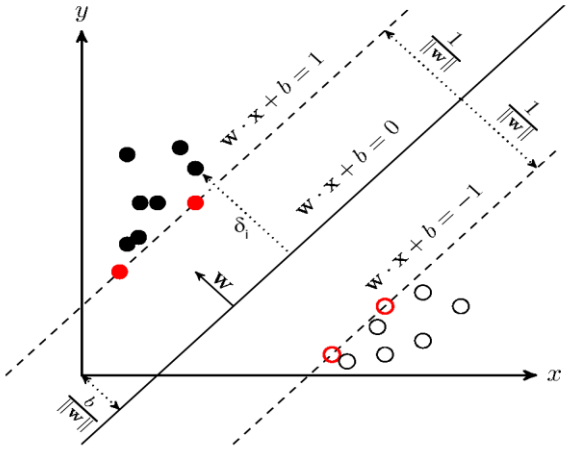

Figure 3. Classification form of SVM.

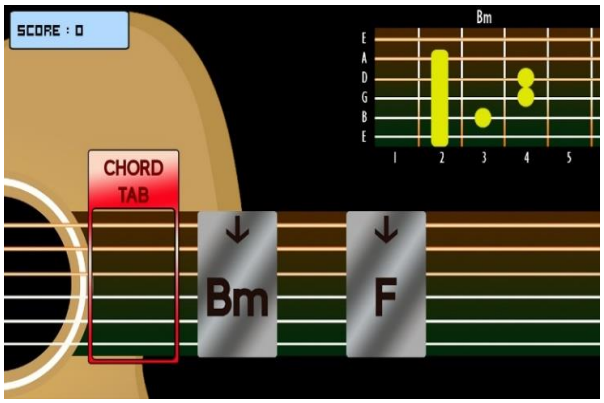

Figure 4. Game display prototype design.

guitar being played is detected by the system and the chord sound is predicted. If the chords played or predicted match the chords of the song, the player gets a score of 100 and if it is wrong, he does not get a score. After the song stops, the game will end and show the last correct score obtained.

A. Dataset Extraction

There are 2200 wav files from the dataset that will be extracted into a chromagram or divided into 12 wave bins, where the extraction of these files is entered into a csv file. This extraction uses the Constant Q Transform (CQT) signal process which is also available in the LibROSA library. Figure 6 is the result of chroma feature extraction in this study.

In the chromagram results, each chord has a chroma tendency according to the type of chord and the combination of notes played according to the chord formula. For example, the C chord, the C chord has a combination of C – E – G notes which correspond to the chroma of the chromagram extraction output. In chords that are divided into major and minor have almost the same similarities but there are still half-tone differences.

B. Training Dataset

After the dataset is converted into csv form, training is carried out from the chroma value on each chord to classify each type of chord into the form of a model from the learning outcomes of the SVM method. The output of this training is a “model” format file. This model will be used for testing at a later stage.

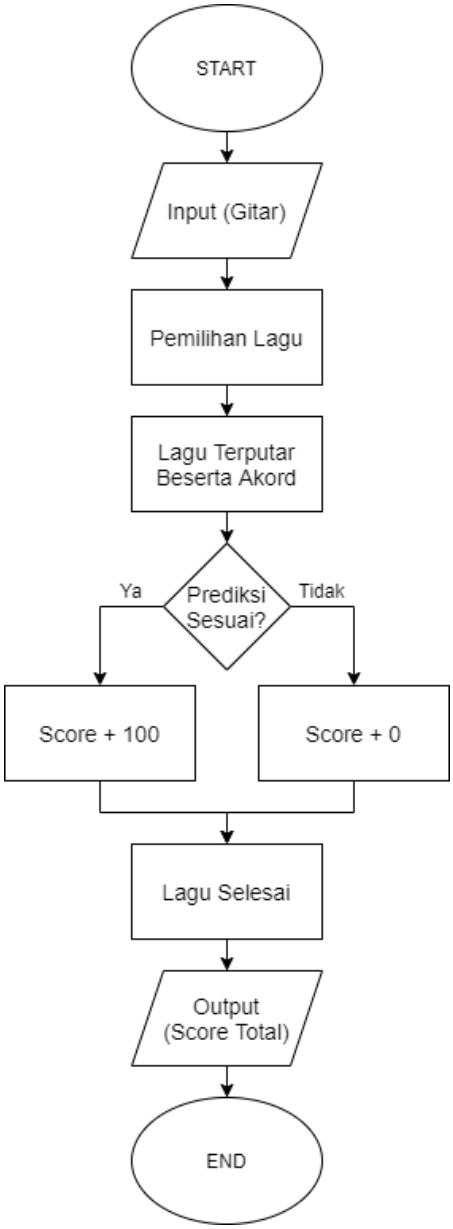

Figure 5. System design of the game.

C. Testing Dataset

To test the dataset, the results of the training dataset (standard hyperplane) will be compared with the training dataset that has been tuned (using hyperplane = -1 / negative). The following Figure 7 is the result for testing the dataset. Figure 8 is the result of the comparison of the model from the previous image in the form of a confusion matrix.

It can be seen from this that during testing there are 41 chroma values that are the same on the A chord and 2 similarities to the Am chord when using the standard model. But when using the tuned model there are 42 equal values on the A chord and 1 similar value on the Am chord. On the D chord, there are 33 chroma values that are the same and 7 similar to the Dm chord, but after using the tuned model there are 39 chroma values that are the same on the D chord and only 2 values that are similar to the Dm chord. There was an increase in accuracy of 3.41% after using the negative hyperplane equation.

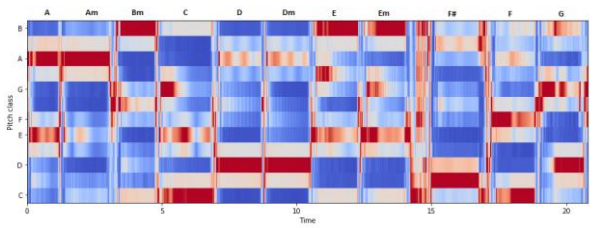

Figure 6. Chromagram of A to G guitar chords.

Standard Model

```
[[41  2  0  0  0  0  0  0  0  0  0]
 [ 0 43  0  0  0  0  0  0  0  0  0]
 [ 0  0 47  0  0  0  0  0  0  0  0]
 [ 0  0  0 39  0  0  0  0  0  0  0]
 [ 0  0  0  0 33  7  0  0  0  0  0]
 [ 0  0  0  0  9 30  0  0  0  0  0]
 [ 0  0  0  0  0  0 35  0  0  0  0]
 [ 0  0  0  0  0  0  1 40  0  0  0]
 [ 0  0  0  0  0  0  0  0 44  0  0]
 [ 0  0  0  0  0  0  0  0  0 31  0]
 [ 0  0  0  0  0  0  0  0  0  0 38]]
```

Tuned Model

```
[[42  1  0  0  0  0  0  0  0  0  0]
 [ 0 43  0  0  0  0  0  0  0  0  0]
 [ 0  0 47  0  0  0  0  0  0  0  0]
 [ 0  0  0 39  0  0  0  0  0  0  0]
 [ 0  0  0  0 39  1  0  0  0  0  0]
 [ 0  0  0  0  2 37  0  0  0  0  0]
 [ 0  0  0  0  0  0 35  0  0  0  0]
 [ 0  0  0  0  0  0  0 41  0  0  0]
 [ 0  0  0  0  0  0  0  0 44  0  0]
 [ 0  0  0  0  0  0  0  0  0 31  0]
 [ 0  0  0  0  0  0  0  0  0  0 38]]
```

Figure 7. Comparison of standard and tuned dataset models.

D. Testing with Music

Because this research is realtime, it is also necessary to test playing guitar instruments directly accompanied by music playing. Here using the song "Hotel California, Eagles" for testing. The reason for using this song is because this song consists of various chords. The chords used include Bm, F#, A, E, G, D, Em. Testing is only done on the intro song. Table 2 is the result of testing using an acoustic guitar.

This test does not include errors that occur due to human error (chord errors by players). In addition, this test was also carried out with standard guitar tuning (E, B, G, D, A, E). It can be seen from the Table 2 there are still less accurate predictions with the same chord base including E major chords with E minor and D major chords with D minor. Because there are 6 errors when playing the E chord, 3 errors when playing the D chord, and 1 error when playing the E minor chord. The following Table 3 is the result of testing using an electric guitar.

There is a significant improvement when using an electric guitar. Now the error result is reduced to just 2 when playing an E chord, but what is detected is still an E minor chord. On other chords no more errors occur. With this in mind, playing this game using an electric guitar is highly recommended for maximum results.

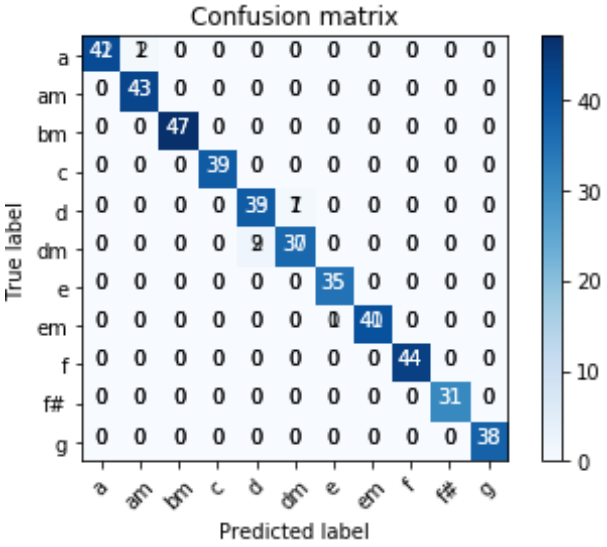

Figure 8 Confusion matrix from comparison.

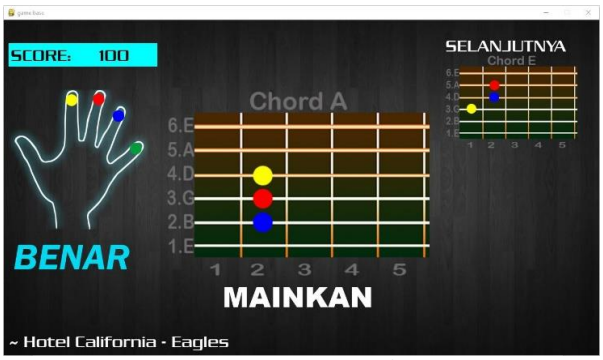

Figure 9. Game display design that has been finished.

E. Game Testing

After the game was built, there was a revision to the interface when playing the game (such as Figure 9), this is because it prioritizes visual chords for people who are just learning. So that the chords are seen more clearly for beginers.

The design that is still maintained is the scoreboard and the shape of the chords that must be played. But in the new design, it now displays the chords that need to be played in a larger size, and some additions such as: finger hints and which finger position to press on the chords, right or wrong detection notifications when playing guitar chords, and information on what song to play. currently playing. Some of these revisions were obtained through suggestions from the results of a previous survey.

F. Surveys and Game Development Suggestions

The survey was conducted with the target audience of computer engineering students. This survey has questions about benefits, interface design, and suggestions. A total of 28 correspondents took part in this survey. The following are the survey results presented in the form of Table 4.

As many as 17 of the 28 correspondents, namely computer engineering students, cannot play the guitar. However, in their opinion to learn guitar accompanied by songs and chords along with detecting the correctness of the chords being played, most of them (21 correspondents) answered that they were very effective in helping them learn to play the guitar. From the interface of the game that has been made, everyone

Table 2.
Testing with acoustic guitar

Music Chord	Testing Times	Correct	Incorrect (predicted)
Bm	20	20	0
F#	20	20	0
A	20	20	0
E	20	14	6 (Em)
G	20	20	0
D	20	17	3 (Dm)
Em	20	19	1 (E)
F#(2)	20	20	0

Table 3.
Testing with electric guitar

Music Chord	Testing Times	Correct	Incorrect (predicted)
Bm	20	20	0
F#	20	20	0
A	20	20	0
E	20	14	2 (Em)
G	20	20	0
D	20	17	0
Em	20	19	0
F#(2)	20	20	0

Table 4.
Survey results,Q = Question and R = Response

Q	**Can you play the musical instrument "Guitar"?**
R	17 correspondents answered "No" and 11 correspondents answered "Yes
Q	**Is learning guitar accompanied by songs and its chords as well as detection of wrong/true chords played can help learn to play guitar?**
R	3 correspondents answered maybe, 4 correspondents answered helpful, and 21 correspondents answered very helpful
Q	**Is the design of the game display that has been made clear and can help learn to play guitar chords?**
R	14 correspondents answered clearly and helpfully and 14 correspondents answered very clearly and helped

agrees that the interface is clear to understand and can help learn to play the guitar.

G. Survei UI dan UX

User Interface (UI) and User Experience (UX) testing was conducted with a survey targeting people who are learning or can already play guitar. Before conducting the survey, participants or correspondents were distributed games that had been made and ready to be used (in \textit{executable} / .exe format) to make it easier for users to operate the game. In this survey, there were 22 correspondents who participated, with an age range of 11 to 40 years and both male and female. A total of 4 participants ranged in age from 11 to 20 years, 12 participants aged 21 to 30 years, and 6 participants aged 31 to 40 years. The results of the User Interface and User Experience survey are presented in Table 5.

For the User Interface survey, the interface of the game is quite understandable from all correspondents but the design of the game needs to be developed and improved so that it looks more attractive and more interactive for users of this game. For the User Experience survey, most of the correspondents think that the games that have been made are quite helpful for users who are learning or beginners to play guitar instruments. The game that has been made is also able to run well from any correspondent device, meaning the game does not require the specifications of a sophisticated device, but still with the Windows operating system.

Table 5.
UI and UX survey results,Q = Question and R = Response

	UI Surveys
Q	**Does the design of the game that has been made look attractive?**
R	1 answered less interesting 11 answered quite interesting 8 answered interesting 2 answered very interesting
Q	**Is the interface that has been created clearly visible?**
R	2 answered quite clearly 13 answered clear 7 answered very clearly
Q	**How to choose the background color of the game?**
R	1 answered is not good 11 answered quite well 10 answered good
	UX Surveys
Q	**Is the game design that has been made comfortable to use?**
R	9 answered quite comfortable 10 answered comfortable 3 answered very comfortable
Q	**Are the buttons or navigation of the game easy to use or easy to understand?**
R	18 answered easy 4 answered very easy
Q	**How is the guitar sound detection feature in the game?**
R	1 answered not good 9 answered quite well 10 answered well 2 answered very well
Q	**How does the game perform when played on your device?**
R	3 answered quite well 9 answered well 10 answered very well

V. CONCLUSION

From the test results, several conclusions can be drawn as follows, The system can predict guitar chords in realtime, each chord has a tone combination that is almost exactly the same as chords in general. The use of a negative hyperplane can minimize ambiguous chord predictions when played. The system error rate for predicting chords in songs with acoustic guitar is 6.25% and electric guitar is 1.25%. Based on the UI survey, correspondents think that the game has a pretty interesting design and it's clear what the game is about. Based on a UX survey, correspondents think this game is quite helpful for people who are learning to play guitar. The game can run well without requiring the specifications of the latest device. For the sake of further development of this final project, it is recommended that the following steps be taken: The use of an electric guitar or a pick-up guitar on an acoustic guitar is highly recommended in this game. Develop a system that has been built to be able to classify more than 11 existing basic chords, including modified, augmented, and diminished chords. Develop a system that can further detect the lead guitar tone or melody, thus also being able to build a tuning system or guitar stem. Improve the interface to make it look better.

REFERENCES

[1] W. P. Malm, *Japanese Music and Musical Instruments*. Tokyo: Kodansha International, 2000.

[2] J. Osmalsky, J.-J. Embrechts, and M. Van Droogenbroeck, "Neural Networks For Musical Chords Recognition," in *Journées*

d'Informatique Musicale (JIM 2012), 2012, pp. 39--46.

[3] I. M. Parapat, M. T. Furqon, and Sutrisno, "Penerapan metode support vector machine (SVM) pada klasifikasi penyimpangan tumbuh kembang anak," *J. Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 2, no. 10, 2018.