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Information Technology, Automation and Robotics

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stages / Yu. V. Nefedov, IA Galperina // Scientific and technical. inform. Ser. 2, Inform. processes and systems. - 2018. - No. 10. - 29 p.

7. Taratukhina, Yu. V. General principles of designing a recommendatory web service for modeling the individual educational trajectory of students / Yu. V. Taratukhina, MS Markaryan // Open and distance learning. Education [Electronic resource]. - 2016. - No. 2. - 77 p. - Access mode: http://journals.tsu.ru/ou/&journal_page=archive&id=1413&article_id=28949. - Date of access: 01.12.2019.

8. Tregubov, AS Development of methods for adapting user interfaces for USSD services / AS Tregubov // Electronic journals of the Notabene publishing house [Electronic resource]. - 2016. - Access mode: http://e-notabene.ru/kp/article_19497.html. - Date of access: 29.11.2019.

GUITAR TUNER FOR ANDROID OS

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Abstract. *The software product was created according to the research. The main function of the program is to process the digital signal and display the corresponding data on the screen of the device, which enables the user to tune the strings on the guitar.*

Keywords: *fast Fourier transformation; sound signal processing; guitar tuner, guitar metronome.*

I. INTRODUCTION

The software product includes a wide range of functionality that will be useful to large users. The main functionality of the program is the analysis of the sound flow, then its processing using the algorithm "Fast Fourier Transform". As a result, the device screen displays the frequency in Hertz, which corresponds to the sound stream, the number and display of strings in the guitar, which is responsible for the frequency and distance between frequency streams and the frequency of the required strings, converted into musical tones.

The program also implements an additional module to display the main guitar chords. The user can view them in various combinations with a specially created graphic element and listen to the sound with the speakers.

Another equally important module is the guitar metronome. A metronome is a device or program that plays sounds at a set speed and is created to help musicians at the right tempo. While playing any musical instrument, it is very easy to lose your sense of rhythm or apply something at the wrong speed. The user, if he arranges money on a guitar or other musical instrument, can set the tempo when it is convenient to play a particular melody. The metronome created in the program programs the rhythm, imitating the game of a real drum beat. Most modern musical works are created on the basis of 4 main acad. Each chord corresponds to a note on the bass guitar. The then module allows you to assign responses to the sounds of the

bass guitar on each of the 4 bars of the melody for quality company.

II. LITERATURE ANALYSIS

The software product is intended for use in the field of music art. Music is one of the key and oldest forms of human art. Regardless of culture, nationality or age, all people have more or less come into contact with music. A huge number of people create new compositions, teach this art to others, or just enjoy this kind of creative activity.

In the process of human development, the art of music has been very active. It was a key part of the culture and folklore of many peoples of the world. It manifested itself in singing and playing musical instruments, which also developed and improved very quickly.

It's no secret that the most popular musical instrument is the guitar. This instrument belongs to the class of stringed instruments, which originate before the beginning of our era. This software product is developed for users who own the game on this tool or are just beginning their journey in learning the basics of the game. The program was developed taking into account the functional needs of musicians.

Each of the 3 main modules will be useful to users. Each time, before playing the guitar, the musician tunes the strings. The Tuner module can help him with this, which will quickly display all the necessary information about the audio stream. Guitar chords are the basis for any musical pattern. The Chords module will allow you to view and listen to all the main chords. Each of your music has its own rhythm, which is followed by a musician during the game. The Metronome module will allow you to adjust the rhythm in the form of a drum beat for any song. Also, if desired, the user can assign a bass guitar part to each of the 4 musical beats of the melody. Accompaniment in this form can best reflect the musical pattern of any song.

The developed software product has all chances to enjoy wide popularity among users. The program has a wide range of functionality that is not inferior to the capabilities of programs with similar purposes.

2.1. Purpose and scope

The developed software product is intended for devices on the Android operating system. The program is designed for a custom audience that is engaged in or studying guitar playing. Three main modules can significantly help musicians.

With the main module "Guitar Tuner" you can tune the guitar, the visual representation displays the current string that is tuned, the frequency in Hertz, which corresponds to the sound flow and the distance to the desired note in half bars.

The "Chords" module will allow you to view the main chords on the guitar, including the location of the fingers on the fingerboard and their order. The user can optionally view different interpretations of chords. If you click on the "play" button, the program alternately plays all the sounds of the chord.

The Metronome module plays the rhythm in the form of a drum beat with the game speed set by the user. This module allows musicians to clearly define and improve the tempo of any composition. It is also possible to add a bass guitar part,

which is superimposed on the drum accompaniment, which improves the quality of the accompaniment.

2.2. Problem statement, literature review, approaches to solving

The problem of sound flow analysis and processing using the "Fast Fourier Transform" algorithm is one of the most common tasks in digital signal processing.

This algorithm is widely used in all devices, one way or another associated with audio signals.

Similar problems have been studied by such authors as M.O. Рибальченко, O.П. Egorov, VB Zvorykin, OV Osharovska, SS Ustinov, OF Мазуркевич, H.O. Patlaenko.

In particular, OP Egorov proposed a method of continuous wavelet transform signal analysis using Fourier transform and to use such an approach to solve such problems. After applying the algorithm, it is possible to draw a graph of the frequency spectrum, which will display the frequencies at which the amplitude of the spectrum is maximum. From this study we can conclude that the frequency spectrum graphs for stationary and non-stationary signal do not differ. The Fourier transform by its nature cannot distinguish a stationary signal from a non-stationary one.

In turn, OV Osharovskaya describes that mathematical models of signals are used for analytical description of signals and processes of their transformation. Signals are considered as functions given in physical coordinates, ie as points and vectors in the functional space - the signal space, which allows you to give a set of signals geometric meaning and clarity. The simplest is the interpretation of signals as elements of a normalized linear metric space. The elements of such a space are called vectors, and a linear combination of independent vectors is called the basis of such a space. One of the most used bases is complex exponential functions (or orthogonal harmonic functions). The decomposition of signals on this basis is called the Fourier series decomposition.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The main algorithm in the software product being developed is "Fast Fourier Transform". Fourier transform - a transformation that compares the functions of a real variable. This operation is performed every time the human ear perceives different sounds. In the human brain, the sound is automatically calculated and converted, which is represented as a spectrum of successive values of the volume level of tones of different pitches, and is perceived in the form in which all people are accustomed to perceive.

This algorithm is used in various fields of science, such as number theory, physics, signal processing, combinatorics, probability theory, cryptography, statistics, optics, acoustics and others. Extensive possibilities of its application are based on a number of useful features which have received the name "properties of Fourier transform":

• This property is known as Parseval's theorem and says that the transformation of a function is a linear operator, which with the corresponding normalization is

unitary.

• The transformation is reversible, ie the inverse result has almost the same form as in the direct application of the algorithm.

• Sinusoidal base expressions are their own differentiated functions. This means that such a representation changes linear equations with a constant coefficient into ordinary algebraic ones.

• According to the convolution theorem, this algorithm converts a complex operation into ordinary multiplication.

• Discrete Fourier transform can be calculated quickly using the Fast Fourier transform algorithm.

IV. RESULTS

To solve the problem of audio stream analysis and frequency search in Hertz, the "Fast Fourier Transform" algorithm in the Kotlin programming language was used.

The user interacts with the product through the software product on the Android operating system, through the interaction with the visual elements of the program. The program consists of 3 main modules: "Guitar Tuner", "Chords" and "Metronome".

The developed product displays the results in the form of animated visual components, which are customized to meet the design requirements of mobile applications. In the "Guitar Tuner" module, the data is displayed as a numerical representation of the sound frequency in Hertz, the current string and the distance to the desired sound. In the "Chords" module, the original data is presented in the form of depicted guitar chords and their sound representation. In the Metronome module, the original data is presented in the form of a drum beat together with a bass guitar, which is played at a user-specified tempo.

V. CONCLUSIONS

In this work, we conducted a study of the problem of sound flow analysis. The result of this study is a software product for the Android operating system, and a detailed report on the work done.

We used the following Fast Fourier Transform algorithm to design the software. The program was created by Android Studio from Google using the programming language Kotlin and XML.

In general, we have developed a software product for solving

tasks of analysis and further processing of the sound signal and frequency calculation in Hertz. The developed software product can be used for tuning or playing the guitar. All major modules have been created to help people involved in the art of music.

There are 3 key modules in the software product:

• "Tuner" - a module that reads the audio stream from the system microphone, analyzes it and displays the corresponding results on the screen to the user. The data is converted using the Fast Fourier Transform algorithm and returns the frequency of

the audio stream. In turn, the module analyzes the frequency and displays information about the current music note and frequency in Hertz.

• "Chords" - a module that allows the user to view all the main guitar chords. You can also listen to chords if you wish.

• "Metronome" - a module that plays the drum bit at a user-specified speed. This functionality allows musicians to play melodies rhythmically and clearly. Functionality for overlaying a bass guitar part on each of the 4 rhythm bars has also been implemented. That is, in addition to the drum accompaniment, another melody will be played.

The testing was performed in several stages. Both individual modules and the program as a whole were tested. Manual tests were created with the help of the Junit frame work and automatic tests with the help of Android Espresso. All stages of testing were passed successfully and the program showed excellent results. The application works at a high level along with programs with similar functionality.

The software product has a number of advantages, such as the speed of input data due to multi-threaded processes, unique functional solutions and design.

According to the results of the study, theses were submitted on

student scientific conference of Chernivtsi National University, as well as a report on PICT-2019.

VI. REFERENCES

1. Leiva A. Kotlin for Android developers: a tutorial. New York: The New York Times Press p., 2017. 191 p.

2. 1. Zhemerov D., Isakova S. Kotlin programming language in action: a textbook. Moscow: DMK Press, 2018. 402 p.

3. Bondarenko VG The unfading glory of the newest Cossacks: the history of the Ukrainian Free Cossacks in Zaporozhye (1917-1920). Zaporozhye, 2017. 113 p.

1. Analysis of frequency and volume in Android. Scribd: website. URL: https://ru.scribd.com/document/215288056/Analyze-the-Frequency-and-Strength-of-Sound-in-Android (access date: 17.10.2019).

2. Frequency analysis in Android. Wayback Machine: website. URL: http://netscale.cse.nd.edu/twiki/pub/Main/Projects/Analyze_the_frequency_and_strength_of_sound_in_Android.pdf (accessed: 15.11.2019).

3. Fast Fourier transform. Sodium Media: website. URL: https://en.sodiummedia.com/4189987-fourier-transform-fast-fourier-transform-discrete-fourier-transform (appeal date: 11/16/2019).

4. Frequency determination using Fast Fourier Transform. Bjorg: website. URL: http://blog.bjornroche.com/2012/07/frequency-detection-using-fft-aka-pitch.html (access date: 26.12.2019).

5. Frequencies for uniform scale. Physics of music-notes: web-site. URL: https://pages.mtu.edu/~suits/notefreqs.html (access date: 15.01.2020).

6. Guitar tuner with microphone online. Acousterr: website. URL: https://www.acousterr.com/guitartuner (access date: 10.02.2020).

7. How to get the frequency of the audio stream. StackOverflow: website. URL: https://stackoverflow.com/questions/11844914/get-the-frequency-of-an-audio-file-in-every-

1-4-seconds-in-android (access date: 03.03.2020).
8. How to record sound in Android with better quality and reduced noise. StackOverflow: website. URL:
https://stackoverflow.com/questions/22282353/how-to-record-sound-in-android-with-better-quality-and-reduce-noise
(appeal date: 15.03.2020).
9. Noise absorption in Android when recording microphone sound. Twigs Tech Tips: website. URL:
https://twigstechtips.blogspot.com/2013/07/android-enable-noise-cancellation-in.html?m=1
(appeal date: 25.03.2020).

YOUNG'S PROBLEM AND ITS APPLICATION

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Abstract. *Today, millions of computers, phones, tablets, and other home appliances work with mobile networks around the world. The problem of providing a large number of devices with high-quality, fast, stable and inexpensive communication is almost at the forefront. An important role in solving this problem is played by the task of optimal, in a certain sense, placement of transceiver stations - nodes of the mobile network.*

Keywords: *Young's Problem; placement of circles; covering the flat surface with circles; minimum radius; minimum amount of circles.*

I. INTRODUCTION

A circle is a part of a plane that lies inside a circle. In other words, this is the locus of points on the plane, the distance from which to a given point, called the center of the circle, does not exceed a given non-negative number R - called the radius of this circle. If the radius is zero, then the circle degenerates into point [1]. A point set is a finite set of points in a plane with fixed coordinates. Coverage circle - a circle of minimum radius, which includes all points of the population.

Jung's Problem is to construct a covering circle for a given point set. By construction we mean the indication of the coordinates of the center of the circle and its radius (diameter).

In this work an attempt is made to adapt a well-known method of constructing a spanning circle of a point set on a plane of minimal diameter to solve such problems [2]. An algorithm was built, a program was developed and the results of its work were tested. Based on them, new tasks could be solved, which have important practical applications.

The developed software product, as a result of the tests showed its full efficiency. The product meets all functional requirements, interface requirements.

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The collection includes student works of the participants of the competition, which were not included in the number of prize-winners. The texts of the competitive works are published in the form in which they were submitted by the authors. The authors of the articles are responsible for the content and form of submission of the material.

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