National University Of Computer and Emerging Sciences

Raks&Roll

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B.S. Computer Science
Final Year Project: May 2018

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Abstract

Raks&Roll is an application that serves the purpose of a virtual choreographer, with the ability to intelligently process music given to it as input and generate a well synchronized dance routine presented to the user in the form of a video. The input audio file is segmented and processed for the extraction of audio features such as tempo, beat timings etc. Different parts of the audio are classified on the basis of these features. Each audio segment is allocated the most suitable dance move from a variety of pre- learned dance steps. These dance moves are then combined to create an output video presented to the user.

The user interface consists of a mobile application. Major processing is carried out at the server communicating with the application. The project encompasses Audio Processing, Music Segmentation, Artificial Intelligence, 3D modelling and Motion Tracking. Audio processing involves the processing of audio based on certain features, whereas, music segmentation is the process of segmenting audio on the basis of music related features i.e. beat timing, beats per minute, time signature (assumed 4/4, as it is most widely used) for this project etc. The audio is segmented based on a predetermined time signature, and then these segments are labeled with features (tempo, beats etc.) extracted from each of them respectively. Motion tracking was used to construct parameters for a dance move, by tracking the movements of a choreographer dancing on an audio of a calculated BPM (beats per minute), hence a unit dance move was labeled by a BPM tag. These parameters were then fed to a 3D model, which would replicate the dance move. The algorithm designed so far maps the extracted BPM of an audio segment and maps it to a dance move with the same BPM, and for two consecutive segments the assignment of dance move also includes the difference in the location of the marked body parts/joints. Hence, producing the best possible smoothly flowing dance from the existing database.

Our work so far can produce a dance routine for the BPMs 60, 90 and 120, as the moves were recorded on these. The routine is not very diverse or smooth due to a very small collection of moves. For future, we intend to use artificial intelligence to gauge the entertainment factor of the dance produced, and also be able to produce dynamic pacing of a move for an extracted BPM that did not exist in the dance data.

Chapter 1: Introduction

Dancing is one of the most popular hobbies across the world, yet only 20% people actually practice it. The rest of them either do not like to dance or are sure that others would not like the way they do it. Our Raks&Roll intends to help you groove to your favorite beat right away, without waiting for any tutorial to be uploaded.

Raks&Roll comprises of a 3D model that has learnt a variety of dance steps that synchronize to a wide range of music segments. Once given an audio file input, audio processing algorithms extract and segment it to map it to the most appropriate dance move.

The project is divided into three major modules, a client, server and one learning module. The client module takes the audio file input and performs the initial audio processing, this processed audio is then sent to the server module and is further processed and matched with the most well-suited available dance moves, which are then compiled and sent back to the client. An additional module will be put together that would keep learning and enhancing the array of learnt dance moves, so that Raks&Roll never gets boring. The music to dance mapping uses artificially intelligent classifiers. Eventually leading to formation of a well-timed choreography, which will help any novice to twirl and twist to their favorite track without the fear of looking off-beat. It's just as they say, "Dancing is fun, but dancing well is more fun".

This project intends to accomplish the designing of a measure of goodness of dance for a given sequence of musical beats, along with segmenting the audio file based on features that impact dance (tempo, beat etc.). It constructs and learns the parameters of a 3D model of a dance performer and will design a language/API to instruct our 3D model for performing dance steps for a vast assortment of musical beats. Another main objective is to devise an algorithm to map the audio file to the most appropriate (for a given measure of goodness of dance) of the available dance moves. It also encompasses a thorough subjective test of the final developed system.

The motive of our project is to aid the creative process of dance making. This system aims to facilitate a user to segment the audio file to provide meaningful information and generate dance dynamically on any audio.

This report in chapter 1 discusses the literature studied to gather information about the previous work and techniques explored related to our project. A brief overview of the functional and non-functional requirements along with high level design of system is given in chapter 3. Chapter 4 gives details about the implementation done so far and the prototype. Chapter 5 and 6 present the test cases and bug report respectively. The conclusion of our work in FYP-I is given in chapter 5.

Chapter 2: Literature survey / related work

A variety of literature and research papers were thoroughly studied for gaining a deeper knowledge and formulating the underlying algorithms for our development project. They are summarized and referenced as under:

1. Dance

Dance has been part of human evolution that reflects the cultural aspects of the society.

1.1 Definition [8]

Dance, in general prospect, is movement of body against a set piece of rhythm from a musical instrument. These movements combined together in a set of sequence can be declared as if someone is performing dance. However the implicit or explicit meaning it portrays is greatly reflected by the context it is performed in. Dance's significance and true meaning can only be depicted if we understand the social, cultural and moral aspects linked to it.

1.1.1 Cultural Significance and Purpose

As linked to a culture, culture evolves over specific period of time so does dance. Therefore it is to conclude that culture dance is to convey meaning of the story that is historically linked to it. Few examples to that are of settlers that have moved into a new area, dance was used as a way of reflecting their positive emotions. Whereas similarly if the area was invaded, dance has been used to convey the hostility to the invaders. As it is one of the ways to convey the history to coming generations [9].

In the modern era, dance even goes beyond its literal and historical meaning. With the ever growing development on social sciences, modern era has adopted dance as proper communication channel to reflect emotions through art of dancing. Similarly making it one of way to tell a story that is universally acceptable. Evolution of technology, especially internet has allowed people from different backgrounds to understand each other and their dances without actually having to experience it physically. An example to that is of social media and YouTube.

Moreover technology has also helped to develop entertainment industry. Even if it dance on stage or offstage or for any other display, it includes a blend and support of sound and lights based on complex software that have been developed for this purpose. These software ensure desired experience and emotions are conveyed under controlled environment. As Marcel J. in The Guardian writes about the combination of light and dance to highlight freedom [10].

1.2 Type of Dances

As discussed, dance is closely linked to the cultural values and norms. In a broader aspects all of the cultures around the globe, are either influenced by the settlers or developed over evolving culture. If we classify the world into regions. American dance culture reflects great variety from modern hip pop to old traditional Native American dances. They tend to reflect the turmoil of the political changes this region has been involved in. European explains the folk and religious influence they have had over the region [11]. African dances has enormous variety, they encapsulate meaning of life alongside religious significance to it. Asia is set of smaller clusters that is grouped together. We can expect to see a variety of culture of such that of India to that of China and Japan. Indian dances reflect the regional centers and their significance. Japan on the other hand develops culture of dance in very early years of development. They tend to entertain and convey folk experience to the viewers.

1.2.1 American Dance Culture [12] [13]

Considering American dance culture has a variety because of the cultural blend present in the society. Dances vary from disco style dancing to street to ballroom. Each type of dance has special qualities and background strong linked to it.

Charleston

This referred to as individual performance as well. Majorly comprises sharp dance movement on musical changes. This type comes under ballroom dance.

Foxtrot

It is another unique form of ballroom dance that goes back to 18th century for its origin. This focus on the changing patterns in the music, especially some of those that go off beat. This syncopation [14] is contrast between rhythm and beat.

Lindy Hop

Introduce by black dancer, became later on recognized by the white dance in the America. Another form of dance for couples, however several new additions were made in this. Especially the spatial movements are more rigorous and accelerated.

Rumba

Introduced in early 1990‟s, another form of dance based on the to and fro motion. This was inspired by the people from Cuba.

Salsa

One of the very popular dances in American culture. This is another one of those that work the most common beat type. This dance is primarily focused on the body movements that will challenge to maintain body balance.

Samba

This is one of few type of dances that is performed solo. It takes its origin from Brazilian dance culture. Majorly works on expressing the uncertainty of half timed beats.

Tango

Referred to the culture of slaves in South America, this is generally a slow dance type. Developed in late 1800's.

Waltz

It is a hard one to differentiate from others, majorly differentiated on the basis of the beat time it is performed. It has its origin linked to heart of Europe.

Hip-Hop Dance

Originates in 1970‟s and yet is to be considered very famous. One of few dances that tend to reflect original street culture alongside a mixture of funk.

1.3 Hip-Hop Dance Background & Purpose

Hip-Pop culture takes its origin in American streets as a non-rural campaign specifically New York City [15] [16] Highlighted by the media in the early 1980's became a true sensation among the youth. Though hardly understood barely in the early days, in about 60 years it has various form in music and dance that are practiced and have been worked on. Generally called "funk style".

1.3.1 Moves & Evolution

These now have well defined categories such as popping, rocking, breaking and social dancing [17]

Popping

Earliest form of development in hip-pop dance. This majorly includes having to move your body in both continuous smooth movements. [18] Also includes movements that make human body vary from plain to plain in sudden motorized motion. Dancers prefer to have upbeat or disco music for this type of dance [19].

Figure 1 Popping

Rocking

This is generally referred as up rock [21]. A more aggressive form of dance with the underlying concept of facing an opponent. Players in groups or individually challenge their competitor by syncing music and dance moves as adversary.

Breaking

This type of dance generally works around the feet hand movement and steady beat flow. The dancer have to make his/her feet sync with the upbeat that is involved in the music [22].

Social Dance

Encapsulates the idea of representing change through dancing in group. However the idea is to represent the fashioned version of protest in terms of clothes and dance moves.

Hip-Hop As targeted dance

Hip-Hop dance is representation of modern dance form. With the aid of technology and global-ness it has evolved in very minute period of time. The evolution has sustained as the dance itself is purposefully and fully conveys the cultural as well modern values acts as the one of the reason we have chosen Hip- Hop dance as targeted dance for our model.

Hip-Pop and Technology [23]

Several researches have been conducted that involve technology at a greater extend to analyze the dance. This is one the indication that we can collaborate dance with technology to come up with new dance routines as proposed in this document.

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One of the researches published under Journal of Music and Dance done conducted by Rie Kojima emphasis on the movements under specific dance move and their relation to conveying and feeling happiness to audience and the dancer itself. This experiment was setup under several cameras where the motion of the dancer was recorded. Dancers included expert dancer as well the novice and beginners in this field. They were provided with the specific dance motion to be performed just under 2 minutes. A skeleton and emotion analysis on the dancer is then developed based and of all the motion they have performed. Finally a correlation between dancers' expression and body movement is developed to conclude that the speed of upper limb majorly determines the emotional significance.

1.4 Motion Tracking

To generate a data set comprising of dance moves, to illustrate our project, we propose to collect a variety of data via Motion Tracking. This motion tracking will be performed on 2D videos and on human dancer via Kinect Sensor, to track dance motions of the model. The libraries that aid motion tracking, and will be used to collect dance data are given as:

Libraries:

PyKinect[24]

Functionalities Offered: For visual analysis libraries, pyKinect2 will be used to populate initial data set of dance moves.
Techniques Used: Uses CPython to provide tracking of human body through Kinect sensor.

1.5 Music

A form of art, music is layering of multiple sounds which combine to formulate an organized sound. Layers can comprise of singing (human voices) coupled with a number of instruments and other musical compositions. [25] [26]

1.5.1 Elements of Music [27] [28]

The most dominant and recurring elements of music are:

1. Beat and Meter
2. Harmony
3. Pitch
4. Rhythm
5. Melody
6. Tempo
7. Texture
8. Dynamics
9. Timbre

1.5.2 Purpose

Music is used as an outlet to channel one's emotions, whatever they might be [29]. It also encompasses soothing and boosting its listener’s morale, providing psychological help and create an ambient atmosphere [30].

1.6 Musical Information Retrieval (MIR)

MIR, is a very vast topic that involves psychology, musicology, machine learning and signal processing.

Definition [31]

An interdisciplinary science of extracting relevant information from music.

Libraries:

Multiple libraries exist that offer extensive functionalities to extract information from music, such as:

1. Librosa [2]

Functionalities Offered: Librosa is an audio analysis library that allows retrieval of features like chromagram, spectrogram, beat, tempo, roll-off frequency etc. from audio files. It also allows to apply effects on audio such as time-stretch and pitch shift.

Techniques Used: Librosa is a music information retrieval package written in python. The package follows scipy and rather than abstract classes, relies on numpy data types and functions. [2]

2. Madmom [3]

Functionalities Offered: Madmom is an audio signal processing library that allows retrieval of features like beats, downbeats, chords, notes, onsets and tempo from an audio file. It also has an evaluation module that contains submodules like key, chords, alignment, notes etc. [3]

Techniques Used: Madmom is written in python. NumPy array modeling is used with no dependencies on other software packages.

3. Aubio [4]

Functionalities Offered: Aubio is a tool for extracting annotations from audio signals. It allows to perform onset detection, pitch tracking, beat and tempo tracking. It also allows extraction of features like mel frequency cepstrum coefficient and phase vocoder.

Techniques Used: Aubio is written in C. A python interface is also designed for Aubio which allows arrays to be viewed as numPy arrays.

4. pyAudioAnalysis [1]

Functionalities Offered: pyAudioAnalysis is an audio signal processing library that extracts features like zero crossing rate, energy, entropy of energy etc. from an audio signal. It also provides classifier and regression models to train and map features of audio signals.

Techniques Used: pyAudioAnalysis is written in Python. kNN classifier is used for classification and SVM Regression is used to perform regression.

Library Preferred:

Librosa was given preference over other audio processing libraries mainly because of its vast and explained documentation and widely available support on Internet. It was also preferred because it offers more built in feature extraction functionalities as compared to Aubio and Madmom.

1.7 Choreography

Choreography is a form of design, which in general is the arrangement of bodily movements to create sequences which depict shift in position [32].

Choreography has different meanings depending on the context, for example in the field of performing arts, it arranges human movements and forms to create dance that is pleasurable to the audience and dancers. Choreography is currently being used in

1. Musical theaters
2. Cheerleading
3. Cinematography
4. Gymnastics
5. Marching band
6. Theatre

The act of choreography is performed by a choreographer. A Choreographer Develops dance through creative exploration and creation of new moves and by arranging variants of previously known dance forms. It is the job of choreographer to synchronize bodily movements to music. It is to be noted that there is a difference between a dance instructor and a choreographer. A choreographer is responsible for producing creative dance routines whereas the dance instructor is responsible for teaching a specific dance form to dancers. It is possible that these two overlap in terms of their duties, for example a dance instructor might choreograph a dance routine and a choreographer might train dancers.[33]

1.8 Relation between Dance and Music

A concrete relation between dance and music has not yet been formed but there are a few aspects of music which are taken into consideration while producing choreographies. Bodily movements to the music is a

natural response. Human body sways to or fro to the sudden burst of energy in an audio stream, in particular the beat and rhythm of music.

1.8.1 Beats, Rhythm and Dance [34]

Usually beats occur at a regular interval of time in music and can be segmented to display stronger and weaker energy levels in an audio file. The variations in these small intervals direct the human movements. While listening to a song with ranging level of tactus human mostly directs his attention to medium energy segments and creates a sequence of dance (Choreography) but can firmly shift focus to higher metrical structures. Human brain is accustomed to identifying these metrical structures naturally (better than any machine or algorithm) and can thus arrange bodily movements to the sensory inputs given to him.

Discussion

Studies related to brain activity and music also confirm the natural predisposition to beats and rhythm in motor areas. When asked to sit still when listening to music Grahn and Rowefound that human while not displaying any physical movements displayed motor reactions in ganglia, PMA, SMA. Moreover, infants when subjected to rhythmic stimulation showed more response than the response showed towards speech.

Studies relating to human cognition by Leman [35] suggests that the beats in the music are the first step towards creation of dance sequence also known as choreography. His claim is that to understand bodily movements to the full extent one must look into complex components of music such as rhythm, melody, time signature and bar levels.

Conclusion

Following this, we can conclude that human body reflects the sensation of music in the form of both motor responses in brain and in the form of bodily movements. However, these studies are all in the preliminary state and cannot simply encompass the complexity of reaction in the form human body movements to musical stimulus.

1.9 Previous Work & Technique Used

This will help us highlight several collaboration between dance, music and technology alongside inducing artificial intelligence to explore ways for developing dance routines through computational theories.

1.9.1 Aim to Explore Dance and AI [36]

Valencia James in her paper about “Kinetic Imagination”, works with set of choreographer to explore various possibilities of combining 3 fields. The aim of this research was to find a common ground between AI and contemporary dance. This type of dance is referred as purely soulful and depicts the meaning of nature through only dance. Therefore in this research the role of music is absent. The researcher proposes that it is possible to work the underlying mathematical model that will enable us to explore dance and motion space. As discussed, choreographer spends hours under developing new methods to portray nature in their contemporary art pieces. Valencia proposes that this process can be speeded up using computational power alongside early developed theories on exploring dance in geometrical space.

Methods to Explore Dance

As the paper is focused on exploring creativity in terms of motion. The researcher have to work through two major challenges. First is to for making computer understand the dance or the motion space itself. Second on developing an algorithm to explore the space in such a way that is achievable by humans as well. First stage is achieved using Kinect to track the motion of a dancer. These motion are in form of joints that are further reduced for simplicity to build this initial research on. After the models have been mapped under a database, system adopts the method to suggest dance steps using randomness. This randomness is further improved using several other parameters such as the developed routine should be

similar to the ones that are being recorded already, however should not be same. It should have the minimum distance to ensure easy and smooth body movement. This allows the software that has been developed under this research to present to user a dance routine in form of moving body animation. As the figure shows development under exploration through illustration.

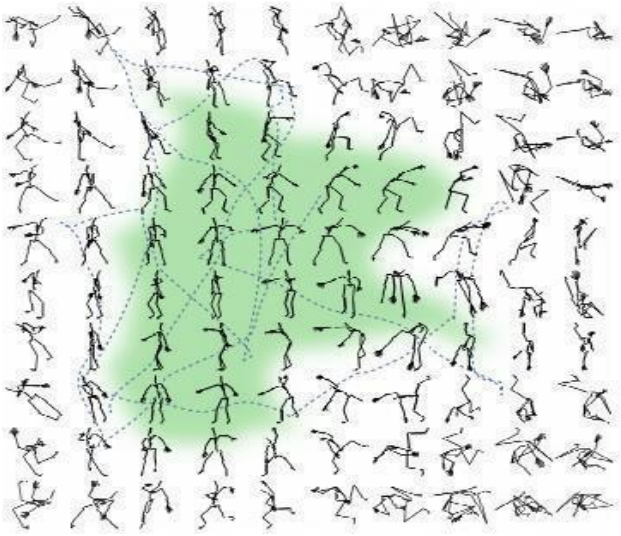

Figure 2. Pose Map

Further on the user can either use blind search: that is to explore all the possibilities under the 2D map of space, or to explore something manually: the choreographer him/herself tries to build a relationship between suggested movements as described by researcher "cherry picking". These motions are then combined to form a way that can be followed for dancing.

Concluding the Method adopted

This research paper is one of the founding steps in exploring the domain of AI and dance. As very basic concept of using search technique is used to explore the possible motion under restricted 2D geometrical space. The further development on same technique has showed that this model can complement the dancer on the runtime as well. [37] Further on the choreographer the system was tested have being surprised by the basic exploration that can help them explore new pathways under joint movement linked to contemporary dance. However we need to ensure that the restrictions imposed on randomness are realistic for developing a doable dance routine.

1.9.2 Creativity and Artificial Intelligence [38]

Artificial intelligence is currently the biggest and most challenging thing in the domain of computer science. Programming our computers to replicate creativity is prime because creativity is pivotal to human intelligence, it can trigger human brain psychologically and emotionally. It also helps induce new creative ideas by providing motivation. Creativity is generally classified as; P-creativity, for psychological creativity where the innovation of the idea depends upon the perception of the individual, and other is H-creativity, for historical creativity where the novelty relies upon the already known information about a particular subject. Primarily, the focus of AI should be modeling P-creativity and in doing so H-creativity will itself fall in line at times.

Types of Creativity and their Modelling

Creativity is generally categorized into three types:

1. Combinational Creativity: It involves traversing the already known ideas and concepts and combining them to generate a newfound, creative idea.
2. Exploratory Creativity: This subtype as the name indicates explores the existing space for concepts and thus, introduces novel ideas.
3. Transformational Creativity: It takes an already known space, and morphs it into space of another dimension.

Computer modeling of AI requires an extensive domain knowledge, a deep set understanding of problem space to be able to define it and enough ability to provide algorithms that provide a view of its potential. Based on these factors, exploratory creativity is most accomplished creativity implementation to date. Whereas, the barrier to implementing combinational creativity is the unmatched associative capacity of human brain. Also, the identification of human values and their depiction in expression is also particularly troublesome for transformational creativity [39].

Generating a system powerful enough to gauge the value of newfound innovation could help us discard the subpar constructions and filter the better ones. This can be achieved through having a heuristic to calculate the betterness of an idea, the hurdle being that human interests are not definitive and always varying. Therefore, to actually provide the count of value of an idea is a very subjective and variable matter.

Conclusion

Major requirements for implementing any creativity require extensive domain knowledge to sufficiently traverse and transform it, if needed. Also, ability to generate procedures to evaluate the domain space, which is critical for transformational creativity.

Relatively, very few models can judge the goodness of their self-created ideas. A far-fetched goal would be to make a model that upon generating even a repulsive and subpar idea can convince us to believe otherwise.

Although realistically, transformational AI has just begun to take the stage, whereas other two type are being used to generate H-type creativity, with many milestones to achieve.

1.9.3 Audio-Visual Beat Tracking Based on a State-Space Model for a Robot Dancer Performing with a Human Dancer [7]

The paper "Audio-Visual Beat Tracking Based on a State-Space Model for a Robot Dancer Performing with a Human Dancer" discusses methods to integrate audio and video queues from the environment to enable a robot to dance with a human on a music. It focuses on reducing environmental noise from music and maintaining a state space model on the basis of input audio signals and visual movements of the dancer to predict the next move. Combining the audio and video queues, a beat tracking system is built which guides the robot to dance alongside a human dancer.

Methodology

A nonlinear state space model is formulated which has tempo, beat time and skeleton features as variables. At every beat time, the current tempo is stored in the space model and the next beat time is estimated by referencing to the history of stored variables. Skeleton features are extracted in 3 steps. First, stopping frames and turning frames are detected as dancers tend to move their joints or stop them at beat times. Then, the detected discrete set of frames are converted to a continuous signal. The likelihood of each tempo is then obtained by applying a Fourier transform on signals of all joints independently. Time fluctuation between the tempo variations and noise of human movement is removed by applying Gaussian filter to produce a state transition model. The next beat time estimation includes 3 steps: state transition, weight calculation and state estimation. The weights are calculated through a derived formula by the authors of the paper.

The internal architecture of the robot dancer contains listening, dancing and singing functions. The listening function is implemented with an open-source robot audition software called HARK which takes an audio signals and identifies the beats and chords of the signal in real-time. The dancing function is applied by assigning 24 different chords of audio with 24 different dance moves. The singing function is implemented in the hardware to generate beat-synchronous singing voices.

Conclusion

The formulation of state space model and through it, performing real-time beat-time estimation has significant potential of being applied in dance applications and algorithms. However, assigning 24 specific dance moves to 24 chords of music reduces the possible diversity of output. The model over- all can be improved by choosing the best move from many stored dance moves in real-time.

1.9.4 Let's Dance: How to Build a User Model for Dance Students Using Wearable Technology [40]

The paper "Let's Dance: How to Build a User Model for Dance Students Using Wearable Technology" mainly discusses the methodologies incorporated in the process of development of a mobile app that tracks students‟ motion data while they perform dance exercises. The hardware used to execute operations in this research is only a smartphone. The goal is to track and record the dance exercises performed by students and present feedback to students afterwards in the form of summaries, visualizations or narratives.

Methodology

This research explains the functioning of the app, or Trainer. Students before initiating their dance routine, must launch the app and place the smartphone in any one of their pockets. The app uses the accelerometer of the smartphone to detect body movements and translate them to BPM through an Algorithm. The time between peaks of the BPM s used to calculate the interval between movements. The results recorded by the app are used to provide feedback to the students in the form of line and bar graphs.

Conclusion

This paper presents a methodology to observe motion data and give feedback to motor learning students. It lays the foundation for more work in the field of dance and observing the aspects of rhythm and dancing skills digitally. However, there are still challenges relating to representation of recorded data in better forms such as a 3d model, and suggesting fixes/improvement to the student for his recorded dance routine on some basis.

1.9.5 Art to SMart: An evolutionary computational model for Bharata Natyam choreography [41]

This paper proposes a Genetic Algorithm based automated system that aids a choreographer in exploring new possibilities. It is specific to an Indian form of dance, called BharataNatyam. For a beat/count, there is a never ending possibility of moves that you could try, but doing that is beyond human capacity. Therefore, the proposed system in this paper provides suitable moves for a beat to a choreographer to aid the creative process and try out unexplored dance moves using genetic algorithm.

1.10 Conclusion

The conclusion of literature review is given in the following table:

Paper	Author	Area of Research	Description
Kinetic Imaginations: Exploring the possibilities of combining AI and dance [36]	Alexander Berman, Valencia James	Artificial Intelligence, Contemporary Dance	A research conducted to study and explore the common ground between artificial intelligence and contemporary dance
Creativity and Artificial Intelligence [38]	Margaret A.Boden	Artificial Intelligence, Creativity	A research conducted to understand the challenges faced by AI to model creativity
Audio-Visual Beat Tracking Based on a State-Space Model for a Robot Dancer Performing with a human dancer	Misato Ohkita, Yoshiaka Bando, Eita Nakamura, Katsutoshi Itoyama, Kazuyoshi Yoshii	Artificial Intelligence, Robotics, Dancing	This paper discuesses methods to integrate audio and video queues from the environment to enable a robot to dance with a human on a music
Let's Dance: How to Build a User Model for Dance	Augusto Dias Pereira dos Santos, Kalina Yacef,	Dance education, Motor Learning, Wearable Devices	This paper mainly discusses the methodologies

Students Using Wearable Technology [40]	Roberto Martinez-Maldonado		incorporated in the process of development of mobile app that tracks students' motion data while they perform dance
Hunting for the beat in the body: on period and phase locking in music-induced movement [34]	Birgitta Burger, Marc R. Thompson, Geoff Luck, Suvi H. Saarikallio, Petri Toiviainen	music- induced movement, dance, motion capture	This paper describes aspects of music that affect dance and how humans have a natural tendency to respond to musical stimuli
Art to SMart: An Evolutionary computational model for BharataNatyam choreography [41]	Sangeeta Yadhav, Manish Joshi, Jyoti Pawar	BharataNatyam Dance, AI	This paper proposes a system that uses genetic algorithm, to provide a set of unexplored dance moves for a beat to a choreographer

Table 1 Conclusion

Chapter 3: Requirements and design

Raks&Roll will be able to generate Hip-Hop choreography for any given audio file. Following are the functional and nonfunctional requirements of the system along with the assumptions.

1.1 Functional Requirements

Following are the functional requirements of the system:

- User would be able to upload a file
  - User would be able to upload an mp3 file
  - User would be able to upload a wav file
- User would be able to save the choreography generated for an audio
- User would be able to play previously saved videos (Choreographies)
- User would be able to delete previously saved videos
- User would be able to manipulate video
  - User would be able to play a video
  - User would be able to replay a video
  - User would be able to pause a video

1.2 Nonfunctional Requirements

Following are the non-functional requirements of the system:

1. Usability

The interface of Raks&Roll is self-directive hence easy to understand and navigate. Minimal information (audio file) is required from the user therefore there is little to no room for error.

2. Security

No specific security concerns since no authorization is required.

3. Compatibility

Our system will be available to both web and mobile (android and iOS) users. Our system will support famous browsers like (Firefox, chrome, edge). Any android user with version 4.4 or above and iOS user with version 8 or above will be able to use our facility.

4. Extensibility

For future we want to incorporate new dancing styles and merge different dance forms to produce fusions. This system also intends to reincarnate late notable dancers in the form of a 3D model that will incorporate their dancing styles and techniques to generate new choreographies, e.g. Michael Jackson.

1.3 Assumptions

Following are few of the assumptions taken:

- Internet is available
- Users should be familiar with the use of android/iOS applications
- Sufficient storage is available to save video
- Android users have an Android version 4.4 or above
- iOS users have version 8 or above
- Time signature of 4/4 assumed
- Audio file of 1 min

1.4 Data Flow Diagram

DFD level 0

Admin is to classify the initial dance moves that are provided by the choreographer. These dance moves are mapped by the system. On the request from the user on given audio, relevant dance moves are formed into dance routine. System also manages the feedback to improve the quality of dance for future requests.

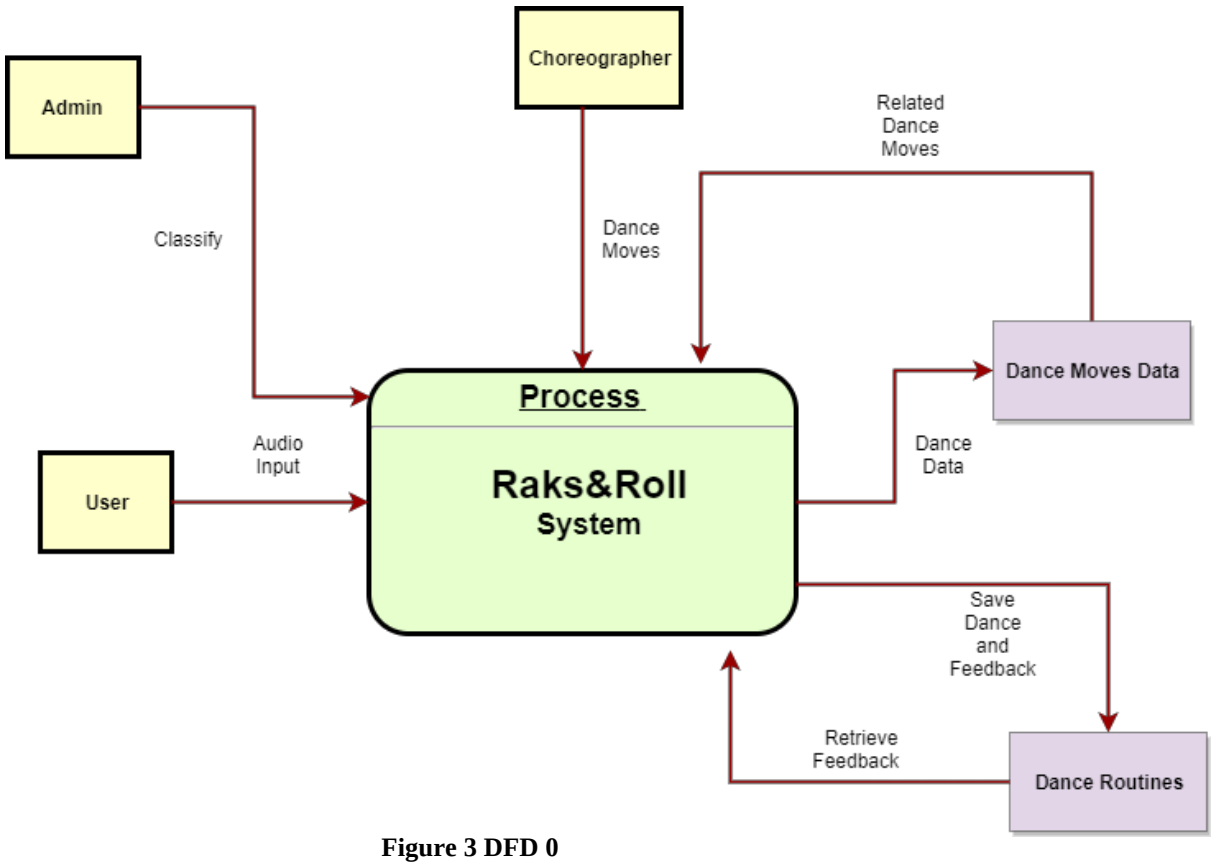

Figure 3 DFD 0

DFD level 1

Dance moves are provided by the choreographer, they are recorded using some motion capture medium. These dance moves are stored. On given request, the audio file is segmented for feature extraction. Audio to dance mapping unit maps the parts of audio to the stored and classified data by the admin. These are then combined to form a dance routine. Respective feedback is also stored into the system for improvement. AI unit uses the feedback alongside stored data to improve the quality of dance.

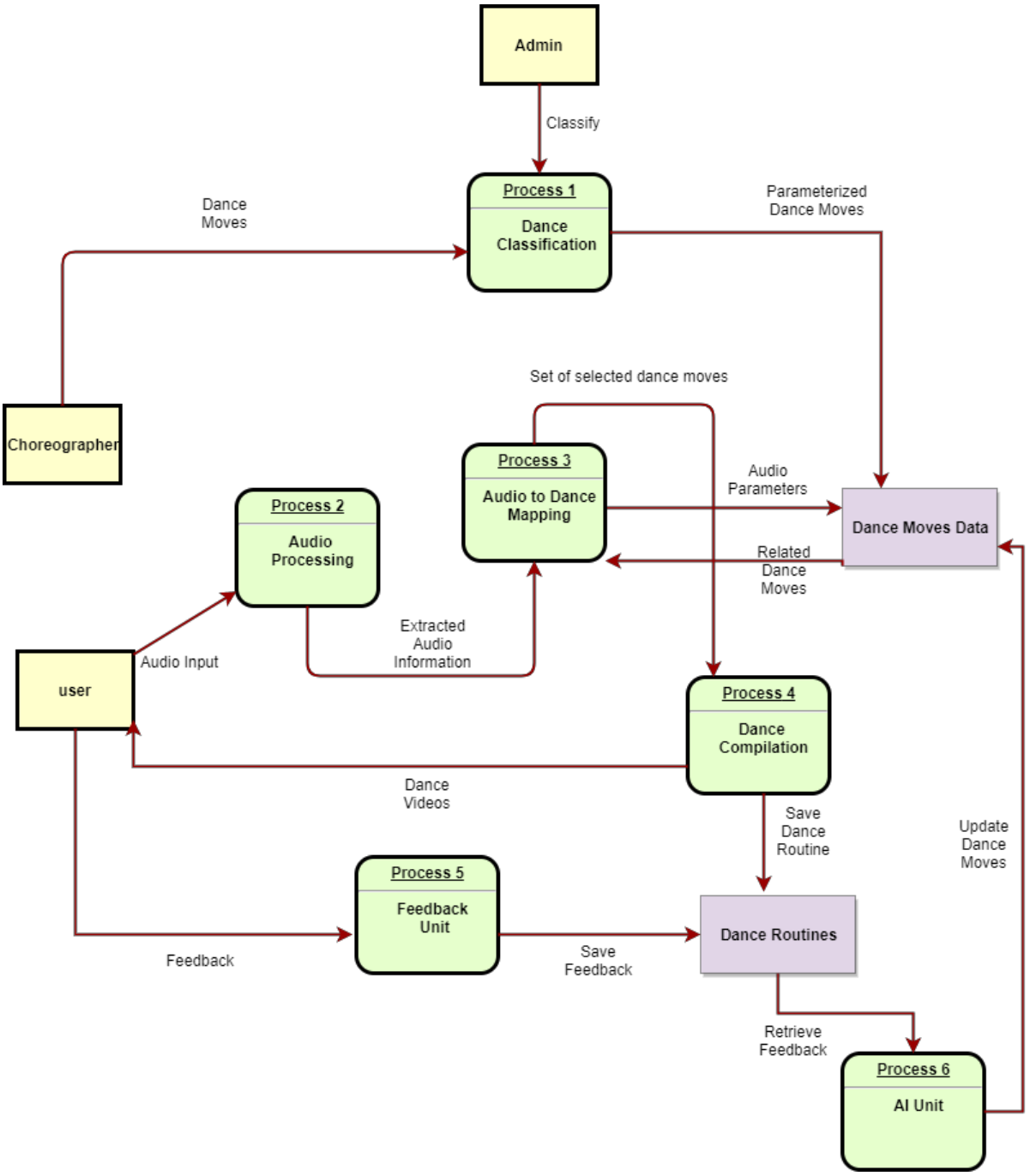

Figure 4 DFD 1

1.5 System Architecture

Our system will be on a server. System functionalities will be exposed using a web and mobile interface. Admin will be able to directly access all the public and private functionalities on the system

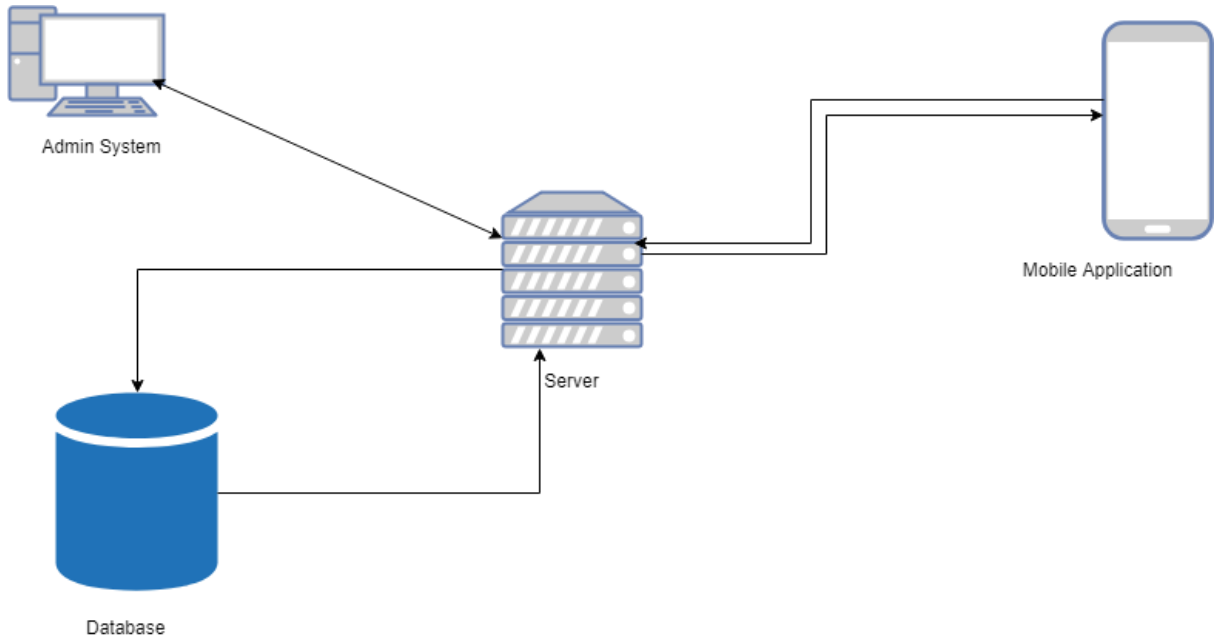

Figure 5 System Architecture

Chapter 4: Implementation

For prototype development, all the modules are not directly integrated. Output of several modules is manually forwarded to the others. Overall, we have collected the data from choreographers and mapped it against the specified bpm. This information is used to develop dance routine after segmentation of the provided audio file. Prototype has been further divided into these following modules:

1. Dance data collection
   Dance data is collected in a motion capturing environment, with a choreographer assisted by music of respective beats per minute. Beats were provided through an app called "Drum Beats Metronome". Beats' rhythm was kept constant so that the choreographer could pace up/down. A single dance step consisted of unique or similar 4-8 body movements. Kinect was used to capture the motion of the choreographer. Motion stream was interpreted using 3D motion builder.

   This data was then trimmed to ensure the exclusion of surplus motion. Trimming includes resetting the position of the "hips" to origin. Trimmed motion was exported into .bvh files. BVH files contain data for positioning of the body parts (for BVH file hierarchy see Appendix B) and their movements at every frame. This data will further be used in identifying dance for specific bpm for forming dance routine.

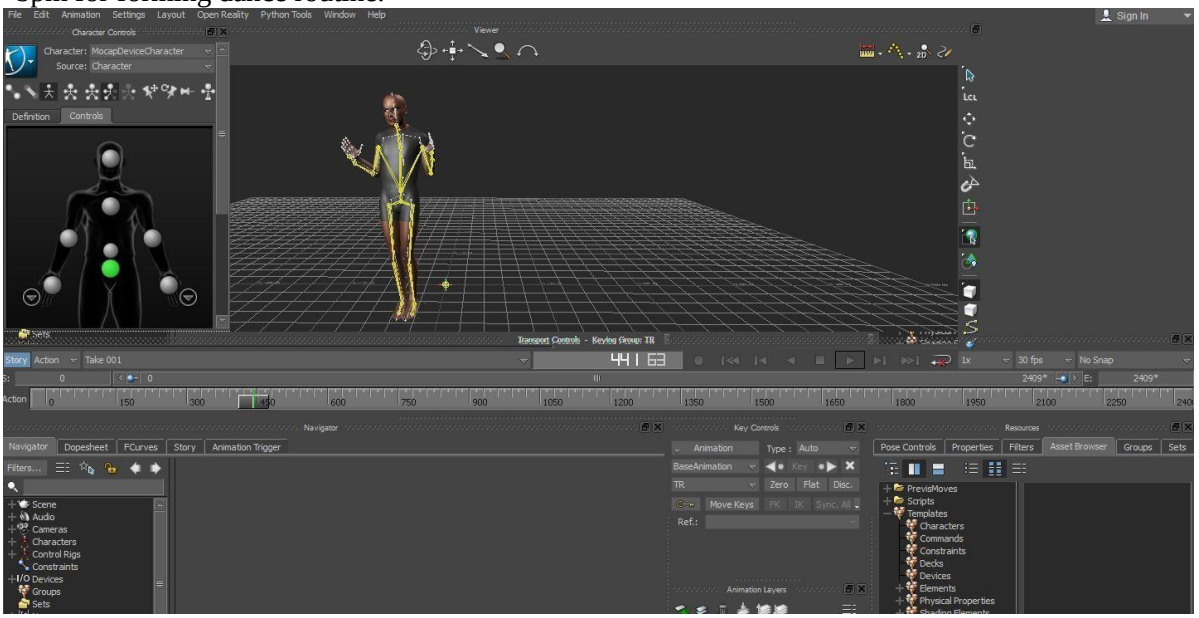

Figure 6 AutoDesk Software

2. Labelling
   The dance steps were classified using following parameters:
   BPM: Dance steps were classified on the bpm they were performed on. For prototype purposes, dance steps were labelled and recorded on the bpm of 60, 90 and 120.
   Body Phase: Defines the body parts that were involved in performing the dance step, for example left hand and right leg, full body and left hand left leg etc.. This classification was performed manually.

3. Audio Segmentation
   Audio is segmented on the basis of the assumed time signature 4/4. The location of the beats is further detected using library librosa (see Appendix A) and Essentia. The audio is then classified to match the respective dance steps under specific range of bpm.

4. Mapping
   Beats segmented are matched with the stored and pre-classified data set of moves.

5. 3D Modelling and Rendering
   Once the dance steps sequence are compiled they are rendered into suitable video format for the user. The video demonstrates developed motion stream onto a character.

6. Server Implementation
   The server is hosted on amazon web services ec2 instance and programmed on Python Django using the REST framework. An API is developed to provide file uploading from the front end. Once the file is received at the server, it is passed as a parameter to the mazy algorithm which returns an mp4 video as a parameter containing the dance routine.

   The video is then uploaded to YouTube from the instance through a python script and meanwhile, the link produced for the video on YouTube is returned to the client as response.
7. Android Application
   The android application provides an interface to upload a sound file to the server as a multi-part request and accept a YouTube link to the video returned from the server. The application also has a local database to store all the links returned from the server and display to the user in future as a list.

8. iOS Application
   Developing an iOS application proved to be a challenge as iOS does not provide access to audio files stored in the phone to applications. Hence the basic features of the application could not be offered to users of iOS platform.

Chapter 5: Test Cases

Test cases design and description. Internet availability is a must for the execution of all the below mentioned test cases.

Test Case ID	Test Case Name
1	Audio Uploading
2	Video Playing
3	Video Pausing
4	Video Restarting
5	Video Saving
6	Giving Feedback

Table 2 List Use Cases

1.1 Audio Uploading

Test Case ID	1	**QA Test Engineer**	Yahya Ali
Test Case Version	1	**Reviewed by**	Moeez Zahid
Test Date	1st May,18	**Use Case Reference(s)**	UC1
Revision History			
Objective	User must be able to upload an audio to Raks&Roll application		
Product/Ver/Module	Raks&Roll Application (client-side)		
Environment	Application should be installed on device for Android		
Assumption	Application must have active internet connection		
Pre-Requisite	Persistent internet connection of application		
Step No.	**Execution Description**	**Procedure Result**	
1	User selects the audio file to upload	System gets the path of audio location	
2	User starts the audio file upload	System receives the audio file and then starts processing it	
Comments:	Our system is working according to our need. It is storing the audio file and then processing it		
✓Passed Failed Not Executed			

Table 3 UC1

1.2 Video Playing

Test Case ID	2	**QA Test Engineer**	Aleena Farooq
Test Case Version	1	**Reviewed by**	Zainab Amir
Test Date	1st May,18	**Use Case Reference(s)**	UC4
Revision History			
Objective	User must be able to play the video generated as an output		
Product/Ver/Module	Raks&Roll Application (client-side)		
Environment	Application should be installed on device for Android User must have access to YouTube		
Assumption	Application must have active internet connection		
Pre-Requisite	Persistent internet connection of application		
Step No.	**Execution Description**	**Procedure Result**	
1	User waits for the generation of dance video.	System processes the audio to generate an output dance video, and then uploads it to "Raks&Roll" YouTube channel.	
2	User receives a notification that dance video is ready.	System takes the link of video uploaded on YouTube and sends it to the user through a notification.	

3	User clicks the link in notification and plays the video on YouTube.	System maintains a list of links to videos generated by a specific user.
Comments:	Our system is behaving as expected.	
✓Passed Failed Not Executed		

Table 4 UC2

1.3 Video Parsing

Test Case ID	3	**QA Test Engineer**	Moeez Zahid
Test Case Version	1	**Reviewed by**	Aleena Farooq
Test Date	3rd May,18	**Use Case Reference(s)**	UC3
Revision History			
Objective	User must be able to pause the video generated as an output		
Product/Ver/Module	Raks&Roll Application (client-side)		
Environment	Application should be installed on device for Android User must have access to YouTube		
Assumption	Application must have active internet connection		
Pre-Requisite	Persistent internet connection of application. User must have uploaded an audio. User must have received an access link to the video.		
Step No.	**Execution Description**	**Procedure Result**	
1	User accesses the video uploaded on YouTube, and can play and pause it as he pleases.	System maintains a list of links to videos generated by a specific user.	
Comments:	Our system is behaving as expected.		
✓Passed Failed Not Executed			

Table 5 UC3

1.4 Video Restarting

Test Case ID	4	**QA Test Engineer**	Zainab Amir
Test Case Version	1	**Reviewed by**	Yahya Ali
Test Date	1st May,18	**Use Case Reference(s)**	UC5
Revision History			
Objective	User must be able to pause the video generated as an output		
Product/Ver/Module	Raks&Roll Application (client-side)		
Environment	Application should be installed on device for Android User must have access to YouTube		
Assumption	Application must have active internet connection		
Pre-Requisite	Persistent internet connection of application. User must have uploaded an audio. User must have received an access link to the video.		
Step No.	**Execution Description**	**Procedure Result**	
1	User accesses the video uploaded on YouTube, and can restart it.	System maintains a list of links to videos generated by a specific user.	
Comments:	Our system is behaving as expected.		
✓Passed Failed Not Executed			

Table 6 UC4

1.5 Video Saving

Test Case ID	5	**QA Test Engineer**	Moeez Zahid
Test Case Version	1	**Reviewed by**	Zainab Amir
Test Date	1st May,18	**Use Case Reference(s)**	UC2
Revision History			
Objective	User must be able to save the video.		
Product/Ver/Module	Raks&Roll Application (client-side)		

Environment	Application should be installed on device for Android User must have access to YouTube	
Assumption	Application must have active internet connection	
Pre-Requisite	Persistent internet connection of application. User must have uploaded an audio. User must have received an access link to the video.	
Step No.	**Execution Description**	**Procedure Result**
1	User views the video from YouTube link, it stays saved there, along with the list of previously generated video links on user profile.	System will provide the list of video links to user which he has previously generated. YouTube stores all these videos at all times
Comments:	Our system is behaving as expected.	
✓Passed Failed Not Executed		

Table 7 UC5

1.6 Giving Feedback

Test Case ID	6	**QA Test Engineer**	Zainab Amir
Test Case Version	1	**Reviewed by**	Zainab Amir
Test Date	1st May,18	**Use Case Reference(s)**	UC6
Revision History			
Objective	User should be able to give feedback on video.		
Product/Ver/Module	Raks&Roll Application (client-side)		
Environment	Application should be installed on device for Android User must have access to YouTube		
Assumption	Application must have active internet connection		
Pre-Requisite	Persistent internet connection of application. User must have uploaded an audio. User must have received an access link to the video.		
Step No.	**Execution Description**	**Procedure Result**	
1	User can like and comment on the video through YouTube.	System will get the response generated from YouTube.	
Comments:	Our system is not currently working according to our need. The feedback system is not fully implemented.		
✓Passed Failed Not Executed			

Table 8 UC6

Chapter 6: Bug Report

Bug 1	Date Seen: 25th Februray,18	
	Submitter: Yahya Ali	Email: l144189@lhr.nu.edu.pk
	Versions: Ubuntu 16.04 Python-django 1.9 Microsoft Remote Desktop 8.0	

Bug Description
While running an ec2 instance on Amazon Web Services, the instance runs out of memory halting the current process execution. The instance did not have swap space configured by default.

Severity
Catastrophic

Steps to Reproduce

1. Open a connection to remote instance.
2. On the terminal, change the current directory to one containing ReadLines.py.
3. On the terminal, type “python ReadLines.py” and press Enter.
4. Wait until processing halts and system runs out of memory.

Actual Behavior
System processing stops and program crashes during execution.

Expected Behavior
System completes process execution normally and returns output.

Troubleshooting/Testing Steps Attempted
We commented major function calls in our code to reduce execution time and memory required by the program. As the program terminated earlier with less memory requirements, it did not crash.

Workaround
We added swap space to the memory of our instance by following the steps mentioned on the web page with url https://stackoverflow.com/questions/17173972/how-do-you-add-swap-to-an-ec2-instance. This permanently solved the problem

Bug 2	Date Seen: 3rd March,18	
	Submitter: Abdul Moeez Zahid	Email: l144168@lhr.nu.edu.pk
	Versions: Ubuntu 16.04 Python-django 1.9 Microsoft Remote Desktop 8.0	

Bug Description
While launching our python django server from the remote ec2 instance on AWS, Sometimes the port we are trying to use is already busy in another process. This results in server not being live.

Severity
Minor

Steps to Reproduce
1. Open a connection to remote instance.
2. On the terminal, change the current directory to one containing manage.py.
3. On the terminal, type “python manage.py runserver 0.0.0.0:8000”
4. The error message may be displayed on the terminal.

Actual Behavior
The command to run the server fails because port is busy.

Expected Behavior
The command to run the server executes successfully resulting in server being live on the public address of the ec2 instance.

Troubleshooting/Testing Steps Attempted
We tried to restart the terminal and restart the instance. This solved the problem as all ports were reset once the machine was restarted. However, this process is time consuming as we have to wait for the machine to be restarted.

Workaround
We killed all the processes assoicated with our port number by following steps mentioned on the link https://stackoverflow.com/questions/20239232/error-that-port-is-already-in-use. This freed the required port and allowed us to run the server.

Bug 3	Date Seen: 12th March,18	
	Submitter: Yahya Ali	Email: l144189@lhr.nu.edu.pk
	Versions: Android Studio 3.0.1	

	Windows 10	

Bug Description
In order to upload audio from android app to server, we needed to select it on the app first. Upon selecting a file from the audio library, the path returned to the application was not proper and could not be used to access the file.

Severity
Major

Steps to Reproduce
1. Open the android app for Raks&Roll on an android smartphone.
2. Press the button “Select file”.
3. Select a music file from the audio library.
4. Return to the app with the incorrect path.

Actual Behavior
Incorrect path for audio file is returned.

Expected Behavior
Correct path for audio file is returned which enables us to access it and upload it on the server.

Troubleshooting/Testing Steps Attempted
We used different ways to parse the Uri returned from the audio library to obtain the path. But this did not solved the issue.

Workaround
Instead of parsing the Uri manually, we used default Cursor object in android to parse the value of the Uri. This returned us the correct and complete path and solved the bug.

Chapter 7: Conclusions

Raks&Roll is a virtual choreographer that takes a music file as an input and produces a synchronized dance routine i.e. choreography. The system has three main modules,

1. Audio processing
2. Mapping dance to music
3. Learning module

The initial plan during FYP-I was to gather as much information as we can about the previous work done related to the project, in the fields of dance, music and artificial intelligence. The findings are reflected in the literature review given in chapter 2. Major portion of the previous semester was spent on learning parameters and factors that influence dance and music altogether. The next step was to define the functional and non-functional requirements that should be fulfilled once the system is in running form. A few assumptions were taken on our part and are also mentioned along with the high and low level design of the system and system architecture in chapter 3.

The scope of our project included segmentation of audio to retrieve meaningful information which we have achieved using the audio processing libraries Librosa and Essentia, as mentioned in chapter 4, where we discuss the implementation details of the system. The second part of our scope was to generate a dynamic dance when given any audio file. So far our system can handle the audio files with BPM 60, 90 and 120. We have motion data for 60 moves which can be mapped to any audio with these specifications of BPM. The test and bug reports are mentioned in chapter 5 and 6 respectively.

The major addition to our algorithm in FYP2 was that we have started considering the local beats tempo in our heuristic function. This ensures that maximum sync in achieved. Moreover we have implemented a website and android application supported by our backend server running on amazon EC2 instance. Android application has a feedback module that tracks the feedback from the user. This feedback is used to list smoothness and beats syncing. This feedback is incorporated into learning module that uses probabilistic model to enhance the selection of moves against songs provided. Moreover we have rebuilt the dataset to ensure that dance moves are recorded with a context to enhance smoothness of final dance routine that is generated.

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Appendix A

```
# Beat tracking example

from __future__ import print_function import librosa

# 1. Get the file path to the included audio example

# filename = librosa.util.example_audio_file()
# 2. Load the audio as a waveform `y`

#    Store the sampling rate as `sr`

y, sr = librosa.load("skater_boy.mp3")

y_percussive = librosa.effects.percussive(y)

# 3. Run the default beat tracker

tempo, beat_frames = librosa.beat.beat_track(y=y, sr=sr)

print('Estimated tempo: {:.2f} beats per minute'.format(tempo))

# 4. Convert the frame indices of beat events into timestamps beat_times =
librosa.frames_to_time(beat_frames, sr=sr)

print('Saving output to beat_times.csv')

#librosa.output.times_csv('beat_times.csv', beat_times)

#librosa.output.times_csv('percussive.csv', y_percussive)
```

Appendix B

```
HIERARCHY
ROOT Hips
{
  OFFSET 15.4709 24.5281 65.8865
  CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
  JOINT Spine
  {
    OFFSET 0 8.4707 0
    CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
    JOINT Neck
    {
      OFFSET 0 37.4109 0
      CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
      End Site
      {
        OFFSET 0 15.2704 0
      }
    }
    JOINT LeftShoulder
    {
      OFFSET 17.3057 37.4109 0
      CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
      JOINT LeftArm
      {
        OFFSET 0 0 0
        CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
        JOINT LeftForeArm
        {
          OFFSET -8.66324e-005 23.585 0
          CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
          JOINT LeftHand
          {
            OFFSET -8.27569e-005 22.5299 0
            CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
            End Site
            {
```

```
          OFFSET -2.84939e-005 7.75728 0
        }
       }
      }
     }
    }
    JOINT RightShoulder
    {
     OFFSET -17.3057 37.4109 0
     CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
     JOINT RightArm
     {
      OFFSET 0 0 0
      CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
      JOINT RightForeArm
      {
       OFFSET 8.66324e-005 23.585 0
       CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
       JOINT RightHand
       {
        OFFSET 8.27569e-005 22.5299 0
        CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
        End Site
        {
         OFFSET 2.84941e-005 7.75728 0
        }
       }
      }
     }
    }
   }
  JOINT LeftUpLeg
  {
   OFFSET 9.03057 -2.13931 0
   CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
   JOINT LeftLeg
   {
```

```
    OFFSET 0 36.7967 0
    CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
    JOINT LeftFoot
    {
     OFFSET 0 22.0122 0
     CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
     End Site
     {
      OFFSET 0 6.57861 3.86504
     }
    }
  }
}
JOINT RightUpLeg
{
  OFFSET -9.03057 -2.13931 0
  CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
  JOINT RightLeg
  {
    OFFSET 0 36.7967 0
    CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
    JOINT RightFoot
    {
     OFFSET 0 22.0122 0
     CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
     End Site
     {
      OFFSET 0 6.57861 3.86504
     }
    }
  }
}
```