Prototype proposal for calligraphic real-time movement rendering

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Abstract

This research starts with analyzing two state of the arts in the field of movement tracking and visualizing, describes the discovered characteristics of movement analysis, feature extraction, and ways of movement visual representation. Then based on the analysis a new artefact is proposed and its design and implementation characteristic are explained. The final program is an interactive real time visualization tool for calligraphic movement rendering, for the purpose of movement retrospection and aesthetic visualization. Movement tracking was done real time through Kinect camera in Processing, through the use of color detection in image processing, for tracking specific color marker to facilitate capturing the position of a specific body part.

Introduction

Tracking and visualizing human movement allows us to further reflect over oftenly unconscious motions, analyze them, or can serve just as an aesthetic form of expression as an artistic creation tool. Both of the purposes allows us to see the expression of the movement otherwise invisible from our perspective in a time dimension, and omnissible becomes expressed in a permanent form. Our mission was to deepen our understanding of movement, explore previously done work around the topic of movement visualization and movement analysis, and design and implement our own new simple movement visualization tool.

Background and related work

This part serves as state of the art in depth analysis. Two chosen works will be described, and their main concepts used characterized, that will serve for deepening our understanding around the topic of movement visualization tools (movement characteristics, visualization, analysis), and as further inspiration toward proposing our own tool.

Interactive Movement Analytics Platform

Mova, or Interactive Movement Analytics Platform, is an analytic movement framework, that was created for the purpose of feature extraction, feature visualization, and analysis of human movement data (Alemi, Pasquier, & Shaw, 2014). As this is tightly connected to our interest for the analysis of existing work and reasoning for it, we decided to include it as our main reference. The research presenting the Mova platform consists of analysis of ways to visualize human movement, describes the functions and types of movement feature extractions, and the presentation of the system design. Final design of the very simplistic Mova platform consists of three components: feature extraction components, visualization engine, and the graphical user interface (GUI). For direct exploration of the tool, one can found it here. In this section we will briefly go through the main concepts in Mova paper.

Visualizing human movement

Visualizing movement and its characteristics can be done through various techniques. Mentioned examples are : video recording, and animated "skeletal information" which is extracted from the tracked human. Multiple national systems by convention exist for describing choreographies and specific set of movement characteristics. Those are Benesh, Eshkol-Wachman, and Labanotation.

Previous analyzed work included on human movement visualization in Mova paper is divided in three groups in terms of their applications: (1) artistic visualizations, (2) movement summarizations, and (3) movement information analytics.
Purpose of those three categories in a brief summarized way: (in the same order) (a) aesthetic visual representations; often in an abstract representational form, (b) synopsis and comparison of the represented content trajectory in a 2D space, (c) further insights and analysis over movement characteristics for evaluating and understanding the movement.

Movement feature extractions

"Feature extraction" is an important aspect of studying, understanding or analyzing human movement. It is to extract and represent its content in terms of set of movement characteristics. Those are often based on the previously mentioned national systems. Extracting features can be done in three ways: (1) using manual annotations determined by a human expert, (2) using algorithmic methods, and (3) using machine learning techniques.

Mova System design

In summary, current prototype of Mova uses motion capture data, that are recorded with a rate of 160 frames per second, and then a subset of key-frames are selected for further feature extraction. The features library includes the information about the type of each feature (position movement, and rotation of each body part). Those output values are then used for further examination of the movement characteristics such as:

- Kinematics: speed, acceleration, jerk.
- Laban effort parameters: space, time, weight, and flow
- Body shape measures (e.g., contraction/expansion of body)
- Gestures (e.g., swipe, drawing shapes, etc) Etc.

Visual representations are then provided by the visualization engine, consisting of representing the input movement feature "clip" and its extracted movement features/characteristics. With the GUI the user can load data and select wished joints and wished characteristics to be visualized (see figure 1 below).

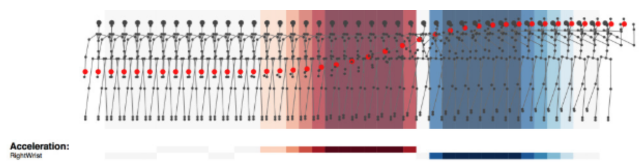

Figure 1: Mova Figure Sketch for a sample of right wrist movement with the values of acceleration projected on it

Implementation techniques

For implementation, Mova is a web-based application, made in JavaScript, built with the help jQuery library for the graphical user interface, and D3 library for the visualizations in SVG format.

While Mova can be characterized as falling mainly in between the categories of movement information analytics and movement summarizations, in the next chapter we will look more at a research presenting purely artistic visualization tool.

EMVIZ: An Artistic Tool for visualizing movement quality

EMVIZ is an example of a real time interactive artistic visualization system, that transform input data into an aesthetic visual representation (Subyen, Maranan, Schiphorst, Pasquier, & Bartram, 2011). The goal of the authors is to communicate complex movement information to an everyday audience, while transforming obscure and complex movement data (its characteristics or qualities) into aesthetically pleasing abstract form.

The representations of human movement qualities are as well derived from the Laban Movement Analysis (LMA) framework. EMVIZ uses data from "wearable sensor classifier supervised learning system." This sensor is used for both, getting the data and also for extracting movement qualities, as part of movement feature extraction. It outputs vectors and EMVIZ then maps the data into "autonomous flocking agents systems and colour palettes". The paper briefly touches the concept of human movement analysis, (with focus purely oriented on the LMA framework) and the main focus of the tool is on the artistic visualization. Main part of the report is then focused on the implementation.

Human movement analysis LMA framework serves for observing, analysing, and describing movement through the view of specific four different components. Those are: Body, Effort, Shape, Space. Movement quality es defined through its effort, and this component rests as main focus, since we are focusing on the movement. Effort has four parameters: Space, Time, Weight, Flow. The "Basic-Effort-Actions" table summarizes basic recognized movement actions and their qualities in terms of the four parameters of the effort. Without unnecessary description, this is outlined in figure 2 below.

Movement Parameter			**Basic-Effort**
Space *Intention or sense of the impact of one's movement*	***Time*** *Decision or sense of urgency*	***Weight*** *Attention to the surrounding environment*	
Direct	*Sustained*	*Strong*	*Press*
Direct	*Sustained*	*Light*	*Glide*
Direct	*Sudden*	*Strong*	*Punch*
Direct	*Sudden*	*Light*	*Dab*
Indirect	*Sustained*	*Strong*	*Wring*
Indirect	*Sustained*	*Light*	*Float*
Indirect	*Sudden*	*Strong*	*Slash*
Indirect	*Sudden*	*Light*	*Flick*

Figure 2: Effort parameters with their extreme values(Subyen et al., 2011)

It is important to note, that the summary on LMA framework in the EMVIZ paper is very brief. It touches the concept only slightly, focusing on the eight basic effort actions, that serves as a main and only categorization tool for movement quality recognition, during the movement feature extraction.

Artistic visualization

Other names for the same category are aesthetic visualization, visualization art, or generative art. The characteristic of this domain are briefly summarized into:

- Its **goal**. This is to reflect, question, explore, in order to abstract the complexity of the "data" (in form of movement this time) so the artist's concern can be communicated.

- **Process**. The process focuses on the goal of reflecting and communicating, through the use of interpretative mapping (finding visual representations), often involving subjective decisions and visual metaphors. Intention during the process is to explore and experiment with the possibilities of creative design space.
- And **output** of the artistic visualization. The output is divided into two categories: (1) one with aim to persuade or change the way people think, (2) to increase aesthetic perception through visual representation. Viewer has then the unconscious responsibility of imaginative interpretation through his own phenomenal observation of the artefact.

The artistic visualization of the movement characteristics is done by color mapping (figure 3) and projecting those qualities into eight Basic-Efforts visual representations, each being a different shape (see figure 4 below).

Basic-Effort	Colour Palettes	Colour Characteristics Associated with Emotion	Motion Quality Characteristics
Press		Power, Nobility, Ambition, Stability, Active	Focus, Straight, Undeviating, Forceful, Leisurely, Lingering
Glide		Comfort, Calm, Faithful, Determination	Focus, Straight, Indulging in time, Easily overcoming gravity
Punch		Anger, Aggressive, Intense, Active	Forceful, Powerful, Fast, Focus, Straight
Dab		Excitement, Energy, Emotional	Focus, Straight, Undeviating, Weightless, Buoyant, Urgent
Wring		Calm, Powerful, Comfort	Forceful, Powerful, Flexible, Spiraling, Slow, Lingering
Float		Calm, Neutral, Peaceful	Buoyant, Wandering, Deviating, Slow, Lingering
Slash		Joy, Excited, Warmth, Dynamic, Energetic	Fast, Energetic, Active, Wandering, Deviating
Flick		Neutral, Excited, Comfortable	Weightless, Wandering, Deviating, Quick, Urgent

Figure 3: Color mapping based on color characteristic associations and motion quality characteristics based on LMA (Subyen et al., 2011)

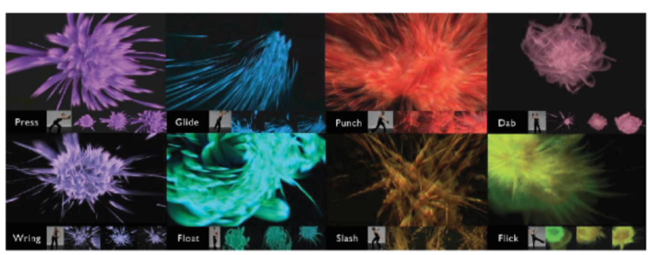

Figure 4: Eight visual representation of Basic-Effort-Actions(Subyen et al., 2011)

Conclusion

Creation of both tools can be broken down into three parts: (1) understanding human movement analysis, consisting of movement characteristic and qualities, (2) feature extraction, that means recognizing chosen movement characteristics and then (3) representing the movement in a visual way, depending on the category where the application (system or tool) belongs, and therefore the purpose or goal of that application. This served as a great starting point for us, and based on this knowledge we designed our own small tool.

Design

This chapter briefly describes the characteristics of the chosen final design. Our aim was to combine the categories of artistic visualizations and movement summarization. The goal was to create tool that would track in real time a specific chosen body part (chosen by user). By taking inspiration from calligraphy, we wanted to make a tool that would "write down" or represent the movement in a calligraphic way. The "transcript" will be then stored and shown to the user after he had performed during specific time span. This becomes his personal data collection of the chosen movement qualities of his, in an aesthetically pleasing calligraphic form. This can then serve as further invitation for the user to try different body part, and try to replicate his "transcript." Additionally, many other potential uses are available, such as comparison of changes in speed, range of space used, and direction of the moves, all that being visualized across time. Meanwhile all this calls for (1) further exploration of his body's capacity to move, while (2) focusing and feeling specific body parts, and perhaps increasing body awareness of those parts, (3) comparison of different body parts. Those are the final goals of the system. Benefits of those potential consequences are beyond the scope of this report to be analyzed.

The next sections describes the three parts of the tool designing process.

Human movement analysis

Tracked kinematic characteristics are speed and the place in the 3D space. The movement speed of acceleration and slowing down, and the scope of the movements (how wide or small they are.) This we consider as the principal characteristics of movement, in the hierarchy of movements, and easily trackable implementation wise.

Movement feature extraction

The captured data that will be further used for displaying the movement in a 2D space, as a color point, detected through camera. Its position will be tracked and saved, and its speed will be characterized by calculating the difference in the point position in between frames.

Artistic visual representation

Interpretation of the movement will be in a form of line. The point's position in space will be reflected and marked in the 2D space, such as when painting. The size of the marker will be characterizing the speed of the movement. The line will move in an uniform speed upwards, so there is always clear space to "draw." However, the latest movement can be seen for the upcoming seconds, so the user still see its shape across time. At the end, when the time finish, the final transcript including all the movement in the time span is shown (figure 5).

Figure 5: Movelligraphy, calligraphic transcript of user's movement

This picture is at the end of the timer saved and exported. Position of the tracked point can be changed, or stay the same, and the tracking can restart.

In the next chapter, we will very briefly describe the process of implementation.

Implementation

Requirements for the implementation are as follows:

- Kinect
- Processing v3
- kinect4WinSDK library or similar

Idea

The idea is to catch specific color from the kinect camera input and use it as a marker for drawing lines on the screen in restricted space while the canvas moves upwards. The user will be able to draw this way for certain amount of time represented as timer. After the timer ends the resulting drawing will be exported into image file. The scaling down of raw input position of the marker will be needed for better visualization of the drawing (more compact result).

Canvas

First step in the implementation was to define the restricted area for drawing. The frame of this area will be used for scaling down the raw position from the input (kinect device). The frame is located in the middle of the screen with scalar sizes relative to the screen sizes (figure 6):

Frame width: 0.25 of screen width Frame height: 0.25 of screen height

Figure 6: Drawing frame on the screen

Image processing

To process the input image from the kinect device we loop through all the pixels and find the first pixel that meets RGB condition (green (c) < 20 && red (c) > 200 && red (c) - blue (c) > 100) which results in pink color of various intensities, since the tracked point was pink. We then scale the XY positions from its raw position to the display size of our window using formula (i/res*w) where i is raw position axis, res is input image resolution axis and w is our screen width. From then on we keep track of the XY positions of the pixel we just calculated. If no pixel was found the default positions [0,0] remains and are later considered as "no marker found".

Data structure

As idea suggests the drawing of the lines based on single points will require storage of the points to be able to redraw them each frame with updated position (visual movement). This is of course one approach as it would be possible to draw the points on object of type Graphic and move the object instead. However, for our generative solution we will need dynamic array ArrayList of PVectors to store 2 dimensional point objects. This array takes new points each frame based on 3 conditions:

- If no points exists: Add a centered point to the array
- If no marker was found in input picture: Copy the last point before with updated Y position and add it to the array
- If marker was found in input picture: add the positions of the marker as point to the array

This system secures the fundamental behavior of this implementation.

Drawing

Based on the array of points we draw the lines between the neighbor points. The thickness line between the points depends on the distance between them. For this we use formula (lineW-(ditance/maxDistance*lineW)) where lineW is the max line thickness. We revert the scalar by subtracting from lineW to increase thickness as the line is shorter. We then have to clamp the result to prevent <0 results since distance can grow much larger than the established threshold maxDistance.

Output

After the timer of the application ends the program re-draws all the lines once again but this time without height being scaled to the drawing frame (width is still scaled for compact visualization). The resulting file is "final.png" and it is located in the root folder of the application.

Conclusion

We introduced a prototype of a real time interactive tool for movement artistic visualization and for human movement analysis. This can be used by non-experts and ordinary users to examine movement in terms of its speed, acceleration, and spaciousness qualities, or just as an artistic creation tool which outcome is a transcript of movement that resembles calligraphic writings. While being in a border of two categories, and additionally taking into account the needed simplicity of the tool for the time available to implement, this tool design fulfilled the aim of providing reflection over the user's movement, and at the same time providing an aesthetically pleasing personal "movelligraphy," (movement+ calligraphy). While staying criticall, further improvements such as research into other topics such as engagement are needed, for the tool to become more user friendly and immersive, and ready to be shared. Until what degree it can be used for analysis especially as a summarization tool is questionable. Other design improvements are:

- More variations of visualization techniques. Including adding the pen "tilting" effect for improving the aesthetic form, option for choosing different colors, etc..
- Increasing the number of extracted features.
- Analysis of the movement done by the system for direct feedback, for example represented by changing colors for specific parts afterwards.
- Intuitiveness of the interface.
- Possibility for combining multi-modal movement data such as video, motion capture, etc. and then perhaps option for tracking multiple points at once.

Further prototype testing is needed for a final evaluation of this artefact and its potential. However, this process lead us to further understanding of the topic, and we believe further iterations and testings can lead into quite potential experimental tool.

References

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