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Movement Awareness through Emotion Based Aesthetic Visualisation

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We present an early system and user studies for visualising movement experience and awareness via an AI based generative art system, which generates an artistic depiction of the state, flow and emotion of human movement allowing the casual user/dancer to be aware of their movement choices. For this initial non-interactive setup, visualisation is based on long exposure photography and expert dance analysis in the form of movement trace forms and emotional characteristics. We evaluate our system through two user studies on emotional reception of parametric generative art and then realise this first stage application in movement awareness artistic (painterly) visualisation.

Aesthetic visualisation. Artificial intelligence. Emotional modelling. Computer graphics. Computation creativity. Movement.

1. INTRODUCTION

Can an interactive aesthetic visualisation system be useful in educating casual or professional users on movement awareness? That is where a user views a generative digital painting and in realising it is their prior movement session that generated it, provokes embodied reflection and awareness of their movement experience (Figures 6D and 6E).

This research focuses on the adaptation of our affective computational creativity system that we have used in art education, art therapy and interactive arts (DiPaola and Salevati 2014; DiPaola *et al*. 2013) into the movement awareness and movement performance domain. The system uses cognitive based Artificial Intelligence (AI) parameters to produce painterly recipes that create unique artworks which can be used to visualise user movement of a performer/dancer eventually in front of the digital canvas to automatically generate an "aesthetic visualisation" based on movement trace forms and various emotion values via painterly abstraction, style and colour (Figures 5 and 6).

With this research we are interested in the user's/performer's awareness and understanding of their movement and their emotional expression through performance within the visual art field. Through our proposed system, a casual user or dancer would view (within 1–3 minutes) a generated painterly artwork of their movement, created from the flow of a short movement sequence they performed (4–7 seconds). This allows them to become an active participant in the art making process as they interactively produce and evolve the style of a generated artwork through the movement choices they make as well as through declared or sensed emotions, thus experiencing art through the creation process.

The proposed system explores an analysis and generation of aesthetic interactive visualisations of art styles with human movement as an expression. While our goal is to create a live interactive system that can sense and remap the movement to aesthetic visualisation painterly form, for this paper we concentrate on the middle and backend part of the system – the movement (with emotion) remapping to generative painting portion of the system.

To validate the emotional remapping for our phase one system, we used long exposure photography of short movement sequences as source input, which were analysed by a dance expert into written analysis and traces form diagrams, rather than live sensed data. Therefore we worked with dancer/photographer Jesús Armand (2014) and his well-known 'Dance Print' series long exposure

photography work (Figures 5A and 6A) because the strong stills of short sequence movement were well suited to our emotion based painterly process and can be theoretically duplicated with interactive AI/digital techniques in the future with cameras and sensors our research group is developing (M+M).

Our process used several long exposure movement stills, which were then analysed by a dance expert using textural analysis and trace forms (Figures 5B and 6B). This firewalled analysis along with the movement stills were used as source to our ePainterly system. The textural analysis of the movement contained emotional assessment of the movement sequence which our system used in the final results based on our two user studies on emotional reception and remapping.

2. DANCE VISUALISATION

The term 'visualisation' with 'choreography' often refers to the ability to realise an artistic idea. While there are still no simple ways to illustrate artistic ideas accurately, there are some tools for doing so. Systems for computationally visualising movement to explore choreographic possibilities without live dancers include *DanceForms* and *DanceVerbs*. *DanceForms* transfers movement data onto interactive avatars as a digital tool for choreography (Calvert *et al*. 1991). *DanceVerbs* explores the animation of movement quality by allowing the choreographer to explore the possible physical qualities of a movement through visualisation of effort and force (Husieh and Luciani 2005).

Carlson *et al*. (2011) describes the design of a movement analysis tool, called ActionPlotthat visualises contemporary dance performances based on the experiential data of a dance expert. Carlson *et al*. use a qualitative approach to extract first person accounts of viewing a recording of a dance performance many times and analyses these experiences to create choreographic information that can be used to visualise the structural composition of the work.

This choreographic information of compositional structure was categorised into three levels. The first level is based on abstracted qualities of the performer such as intention and direction of gaze. The second level is based on quantitative information such as the number of performers, amount of effort, time and tempo. The third level represents the balance of movement in the body. Carlson maps these three levels of choreographic information with visual elements and assigned them to a reference point for low, middle, and high numbers. Dancers are defined by colours such as teal, aqua, yellow, purple, green, and red. Intention and gaze are represented as a circle. Intention was mapped to the diameter and direction to line weight on the edge of the circle. Lines are represented as time while the amount of effort is mapped to x and y coordinates. The visualisation output is similar to a two-dimensional diagram, such as line graphs in traditional visualisation practice.

3. EMOTIONAL EXPERIENCE AND VISUALISATION

Our research attempts to engage user emotion as both a social embodied process in art and painting, as well as a notion of a movement expression and intent. We want to focus on the emotional journey while interacting with a generative art piece and involving our performer/dancer in the creation process through movement. This spiral of experiencing, reflecting and meaning-making provides a participatory platform for co-creation of ideas, which is visitor focused, open-ended and prepares the viewer for broader, richer, learning experiences. This user experience process, by exploring the various palette, brushstrokes and texture through dance provides a visualisation tool which can add to the art making process by providing the performer with an interactive experience to better understand and connect with their body in space.

Incorporating affect and affinities within interactive experiences can be challenging as they need to be open- ended in order for the users to be able to orchestrate their own emotional experiences. Hence, we wanted to provide the visitors with an activity to construct their experience out of what is important and meaningful to them, allowing for that personal encounter.

This experience allows for personal storytelling, where the viewer can formulate and develop their own narrative of their painting through the various movement and emotions. Identity, like interest, develops through interaction; both interest and identity develop in relation to available experiences and to how learners perceive, understand and represent these experiences. Our intended interactive process provides an environment where viewers become co-authors; through participating in the visualisation of their performance, and personalisation of the artwork based on their mood and emotion that only relates to them in that moment of interaction. This interaction enables viewers to learn by creating knowledge through experimentation and formation of purposes driven by their curiosity, interests and emotion.

4. PAINTERLY RENDERING

In this work, we use AI based portrait painting algorithms with an automatic multi-objective genetic

algorithm. We employ an existing cognitive-based NPR toolkit for the function of genotype-to-phenotype renderer. Evolutionary algorithms such as genetic algorithms (GA) employ software techniques derived from natural evolution to find an optimised solution within a large search space. A new field emerging in artificial intelligence is 'creative evolutionary systems' (CES) which attempt to evolve aesthetically pleasing structures in art, music and design.

Non Photorealistic Rendering (NPR) is a computer graphics technique, which creates imagery with a wide variety of expressive styles inspired by painting, drawing, technical illustration, cartoons and mapping. Our system uses an automatic multiobjective genetic algorithm (MOGA) in non-photorealistic rendering (NPR) that allows the evolutionary process to run without stopping for human input. We used this MOGA to generate classes of creative painterly recipes for this research work.

Painterly is an NPR toolkit, which uses a knowledge- based approach to painterly rendering to create a wide variety of computational paintings styles based on source portrait photograph and semantic knowledge maps (DiPaola *et al*. 2010, DiPaola 2009, DiPaola 2007). The knowledge rules were sourced/encoded by categorising traditional 'artistic painter process' and linking the findings to theories from human vision, colour and perception, as well as semantic models of the face. Using this knowledge domain, the system attempts to act on the same semantic level as a human painter might. This qualitative knowledge is parameterised into high level (cognitive processes called Thinkers) and low-level parameters (painting actions called Painters). These parameters are what we automatically evolve using our MOGA as scripts to render a painterly recipe style.

Painterly has contributed to research understanding in the cognitive nature of art and vision science, mainly with in empirical techniques (i.e. eye tracking studies) that allow images to be varied in systematic ways while still being judged as plausible works of art (DiPaola *et al*. 2010, DiPaola 2009, DiPaola 2005). However it is still difficult for researchers/ users to script the scores of parameters to make a strong painterly recipe. Painterly has three main sections. The first 'Thinker' section mimics the cognitive high level painterly process deciding progressively detailed passes and the cognitive blobs (shapes) that painters work in. Next the 'Painter' section implements the Thinker's plans in low-level variables of brush', size, length and transparency per pass and per cognitive blob. Lastly, a colour system translates tonal value into final colour based on the semantic regions (eyes, clothes, etc.) of the destination painting.

In this paper we report on taking those evolved recipes that are most emotively receptive and categorising them via two user studies based on emotion reception to their painterly output. We have added additional modules in our Painterly system and therefore refer to this updated module as ePainterly (e for emotion). ePainterly, takes source photography and filters it through computer modelled art techniques using algorithmic, image processing and Perlin noise sub-modules to generate colour palette, stroking and style techniques associated with modern art painting to affect emotional reception.

4. EMOTION BASED USER-STUDIES

We have conducted 2 studies to understand the mood, affect and emotion that are evoked from the artworks produced by our authored ePainterly system. Our studies have provided us with data to inform and define various validated emotional spaces within our environment. The surveys identified corresponding emotions selected by majority of viewers of the various artwork (the painterly recipes) produced by ePainterly. We concentrated mainly on mapping of the mood to texture, brush strokes and palette.

4.1 Study 1 process

Our first study focused on affective assessment. Here we take as inspiration the works of Rosalind Picard's work on affective learning (Kort *et al*. 2001) that propose an emotion model built on Russell's circumplex model of affect (Russell 1980) and works of Sundstrom, Stahl and Hook's emotional mobile messaging (2007) work that map that model to a palette. Russell's proposed circumplex model categorises emotions by two axes of arousal and valence. Arousal represents the energy and activation of an emotion including high (positive arousal) and low (negative arousal). Valence describes the pleasure (positive valence) and displeasure (negative valence) of emotions (Russell 1980). We used this model for the emotional assessment in our two studies. We choose the following 12 emotions in 4 different categories (3 from each quadrant of Russell's model): excited, delighted, happy – satisfied, relaxed, calm – tired, bored, sad – frustrated, angry and afraid.

There were a total of 30 study participants (Aged 20–45, 11 male, 19 female). We ran a total of 3 surveys, including 10 images in each (10 painterly recipes) with different seed files. We wanted to confirm that each recipe (i.e., painting instruction script) within our system regardless of the subject matter would trigger and arouse the same feeling and emotion in our subjects. We wanted to de-couple the content from the influence of visual attributes on mood. Our goal was to map the

palette, brushstroke and texture to a particular emotional space.

Procedure: each survey was 6 minutes (35s per photograph) and participants had the option of choosing a primary emotion and secondary emotion that they thought best matched each image as "humans rarely associate definitive emotion with pictures and believe that great works of art evoke a mix of emotions" (Joshi *et al*. 2011). Therefore we provided the participants with categories that are not completely independent, where the primary and secondary options allow them to define a space and correlation between two different emotions.

4.1.1 Study Results

The results of the study provided us with preliminary data to inform and define various spaces within our ePainterly based environment (Figure 1).The survey identified corresponding emotions selected by majority of viewers of the various artwork (scripts or recipes) produced our evolved painterly recipes. In our synthesis we were able to identify recipes within each quadrant, particularly four that were most selected by our participants. Each ePainterly script (recipe), which has several levels of parameters to create different hierarchical layers of colour palette, stroke and style deviations. The recipes have archaic names like 'P12P32' based on the calling script to ePainterly, which we will refer to in the next sections.

The Study 1 findings can be summarised into the following quadrants based on visual attributes and the most selected corresponding recipe (the extreme 4).

Quadrant 1: Excited, Delighted, Happy (Recipe P12P33)

- Palette: bright red, pink, orange
- Brush Stroke & Texture: high pigmented, defined, contrasting, bold (Chiaroscuro, opaque)

Quadrant 2: Satisfied, Relaxed, Calm (Recipe P12P12)

- Palette: deep and light green and blue
- Brush Stroke & Texture: soft texture, blurred, informal

Quadrant 3: Tired, Bored, Sad (Recipe A06)

- Palette: soft purple, pink, navy blue
- Brush Stroke: blended, transparent, soft (scumbling, glaze)

Quadrant 4: Frustrated, Angry, Afraid (Recipe A07)

- Palette: deep purple, magenta, red
- Brush Stroke: swirly, intensified, saturated, bold (opaque)

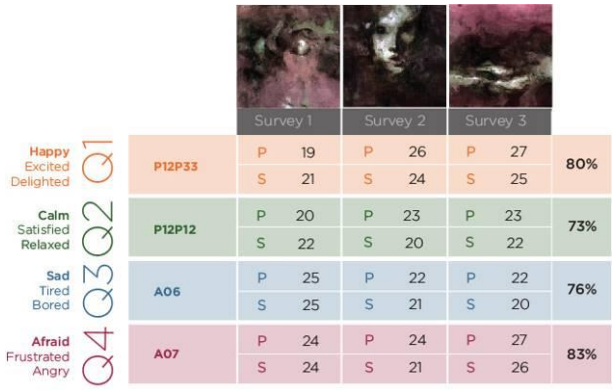

Figure 1: *Results from our first study.*

We also visually mapped the placement of these recipes within Russell's Affective Model (Figure 2) to document the variant degrees of the emotions portrayed by each image. We designated a space to each recipe based on the calculations of primary and secondary tagged emotions.

Figure 2: *Visual Map of our survey results.*

4.2 Study 2 process

This second study aimed to validate the results from our first survey study. Due to the fact that our research focuses on human subjects – how they perceive themselves, how they move -- eventually in the form of an interactive system as an investigation of various affect and emotion, we wanted to confirm our findings (emotional mappings) through a self-portraiture emotional assessment.

This second study included a total of 20 participants (Aged 20–45, 10 male, 10 female) that were not involved in our first study. Each participant using our interactive system had their self-portraits taken. This photo was then processed through our ePainterly module with the four identified painterly recipes found as a result of our first study (Quadrant 1–4). These four generative art portraits (Figure 3) representing the different emotions (via palette, brush stroke, texture) were then shown to each participants at high resolution for them to self-

assess and match their portraits with different quadrant of emotions based on Russell's circumplex. The purpose of this study was to affirm that our four ePainterly emotional recipes (from study one based on non-content specific artwork) match with study two participant's emotional evaluation of their own self, as self- portraits. It was deemed valuable to start with emotional abstracted art of the 'front on' portraits of the self before we moved on to individuals seeing themselves in motion.

Figure 3: *Portraits of one our participant's photo, Jordan, based on the 4 emotional recipes from our first study.*

Procedure: each participant took about 3–5 minutes to examine each of their 4 self-portraits in high-resolution / full display size and after proceeded in matching each photo to the different emotional category (Russell's quadrants of emotion) provided. After an unstructured interview they provided general feedback about their reaction to our ePainterly based generated art portraits, picking their favourite, and gave reasoning behind their emotional category selection and which portrait they most related to at that moment.

4.2.1Study 2 results

The findings validated the emotional mappings of our recipes identified through the first study. The majority of our participants (80–85%) matched the correct recipe to the corresponding emotional quadrant (Figure 4). The participants found that the portraits were striking, unexpected and at the same time strange to view.

They were able to relate to all portraits as they recognised the emotion that they evoked through the different palette, brushstroke and texture. They felt that each generated painting expressed and brought out their essence in a different way. For instance 15/20 participants picked the "Happy (P11P32)" as their favourite due to the energetic and positive emotion it triggered. Based on our findings it is evident that our recipes have captured our intended affect and mood.

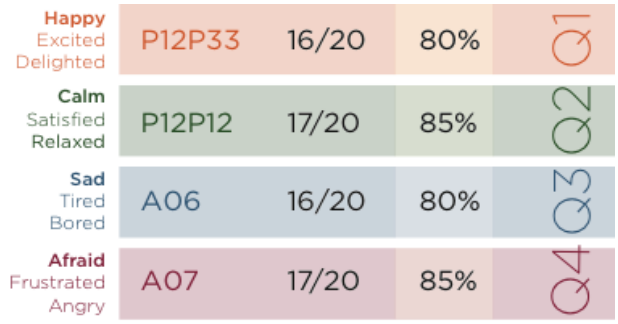

Figure 4: *Results from our second study.*

5. AFFECTIVE AESTHETIC VISUALISATION

Our two user studies have confirmed our approach to designing interactive experiences where emotion can be an active parameter within several domains and applications. These include: computational creativity, affective aesthetic visualisation, experiential learning in museums (art education), health well-being, and performance visualisation (dancing) (Salevati and DiPaola 2015).

Within the art education domain (DiPaola and Salevati 2014) our Creative AI interactive experience complements the traditional art viewing process by allowing users to explore various palette, brushstrokes and texture to improve their understanding and connection with the Artist's creative process and emotional experience. This promotes engagement and active learning within museums by facilitating deeper personal appreciation of artwork through immersion.

In the health-wellbeing sector we explored its application in the therapeutic domain, where we engage patients in a creative process to redirect their fear and anxiety through a positive distraction; bringing a refreshed perspective to the mission of healing. Through the use of our AI, patients are presented an affective visual sensory application (emotional based portraiture) that provides the calming stimuli that supports healing (DiPaola *et al*. 2013).We see a great potential of the adaptation of the system within the movement awareness domain and the aesthetic visualisation of emotional expression through performance.

The ultimate goal is to design systems that act as both a support tool engaging some cognitive load of creativity, and also to provide a poetic and intuitive user experience that evokes reflection through interaction. Therefore the goal of this work is to better understand movement through aesthetic visualisation by establishing a dialogue that supports affective knowledge exchange in a non-linear interactive experience – promoting collaboration and active participation between user and the AI systems based on emotional mindfulness.

6. MOVEMENT AWARENESS THROUGH VISUALISATION

While our stated longer term goal is to create an intelligent interactive system that can automatically sense and remap human movement to aesthetic visualisation in a live setting, which better promotes iterative experimentation and reflection, we now document our work to demonstrate the feasibility in the middle and backend remapping process – that is the emotional/movement remapping to generative painting portion of the system based on our study results.

Here we use our validated four emotional recipes, with movement source material to generate painterly output from previously captured rather than live sensing. Therefore we worked with dancer/photographer Jesús Armand and his 'Dance Print' series which capture a short movement dance sequence as long exposure photography (Armand 2014). These prove to be a good test case of the robustness of our system and analysis process, since these captured dance movements were not made for our purposes. As stated earlier, Armand's capture process, while it also works well with our first pass system, seems valid as early test source since theoretically we can duplicate the optical motion blur and strobe techniques he uses with interactive AI/digital techniques in the future using 2D / 3D cameras and sensors setups our research group is developing (M+M n.d.). Our process then used several of his long exposure movement stills as input source. Without an automated intelligent analysis process in place, we also used a human dance analyst in its place. We allowed the expert to choice 'Dance Print' motion stills and then to categorise the captured movement in these photographic documents. The dance expert with Laban Movement Analysis and Alexander Technique training who was not given prior knowledge of our emotional e-Painterly process, was instructed to document textual analysis of the motion sequence. They were instructed, within that written documentation, to choose an emotional quality of the movement captured, limited in this first phase to our initial four (Happy, Sad, Calm or Afraid). They also were instructed to use other movement analysis techniques they deemed appropriate for 2D visualisation of movement. They decided to create trace form lines of the major limbs (Figures 5B, and 6B). This 'firewalled to the process' movement analysis along with the movement stills was used as source to our ePainterly system, including the emotional assessment from the textural analysis.

Besides the text analysis below the dance expert created trace forms over long-exposure photography of dancers to highlight the trajectory of their limbs over time. The action of creating the trace forms they believed would help users understand kinesthetically how the movements were performed by deconstructing the movement steps. The expert then analysed the movement images for their affinities to map their actions to metaphorical affect using a movement analyst in training. Excerpts of 'firewalled' textual analysis of two of the movements follows:

> In Figure 4A: "This dancer would have entered the frame space by taking two steps to twist into an arched jump facing the direction he entered, landing and moving to his right or backwards to exist the space. The body position appears to have used a cross-pattern to provide propulsion to jump and twist in the air, enabling the engagement and opposition of the core muscles to propel the body. The arms would support the movement by scooping up the midline of the front of the body and into their respective ballet placement, supporting the expansion of the upper body and extension of the limbs at the height of the jump. The dancer would be shifting from a near/ mid to far reach space, moving in a middle to high level in the horizontal to vertical plane. The suspension of time eluded by the camera and the attention to presentational space (in front of the body) could relate to **'happy'.**
>
> In Figure 5A: "The dancers started upstage and travelled towards the camera for the jump, then split to exit on opposite sites. Affinities of the body position illustrate limbs extended to their respective sides, without crossing over the midline of the body. Due to the body's structure this enables the greatest range of motion and possibility for movement, with the freedom to choose opportunities. However this can also lessen the available strength to execute a movement, which could mean that the movement is lighter in weight effort (how operating with resistance). The male partner is utilizing the opposition of gravity to propel the female partner higher in the air, though again does not need to use core muscle strength to do this. The photography provides the illusion of a suspension in time, which could suggest an impactive phrasing, needing a strong propulsion from the group to jump and suspend in the air. Light, suspended effort qualities combined with an

> open and extended body position in high space could be interpreted to be in the 'happy' space, however without seeing the take-off from the jump (where we could evaluate the amount of weight effort used to propel off the ground) it is difficult to tell whether the jump would look punctuated an 'excited' or even and **'calm'."**

Using as source input the 1) long exposure images (as the captured movement), 2) the trace forms and 3) the assessment of the emotional possibility of the dance movement in each piece (for Figure 5 it was "happy" for Figure 6 it was "calm"), our ePainterly system automatically generated abstracted art visualisation of that movement sequence (Figures 5D and 6D). As part of the process, the analysed trace forms markings were incorporated into the original photographically captured movement, abstracting into the work which allowed ePainterly to add to and emphasize the movement arcs in the final painterly visualisation.

Figure 5 shows A) the original captured movement sequence by Armond, B) the trace lines, C) the possible four emotional outputs and D) the final visualisation the system would show to the user. Our goal is that a movement user would appreciate the final generated aesthetic visualisation, and become more aware of their movement authoring the work in successive iterations, thereby bring heighted attention to the complex movement experience of their bodies. Figure 6 shows a second captured dance movement that the expert deemed as "calm". We also document all the ePainterly emotion recipes for the two movement captures as well as the one the expert choose based on the analysis for comparison (Figures 5C and 6C).

6. CONCLUSION AND FUTURE DIRECTION

We present our prototype system design, emotion based painterly stroke, palette and style, user studies and generated output from captured and analysed test movements in our ePainterly aesthetic visualisation, movement awareness research. We showcased the Calm versus Happy emotional recipes for the two captured movements along with the visual trace forms both within the abstracted work and layered as corresponding coloured lines. We believe this can add to a more experiential, intuitive visualisation of movement and provoke embodied reflection and awareness of a user's movement experience.

For our preliminary exploration, we used a limited set (4) of emotions from the Russell circumplex of affect space, but given our process we believe we can open that set up to not only additional emotional qualities of movement, but other creativity based categories to remap into Painterly rendering space. As well with a strong process for the remapping from this initial research, we are now interested in moving to a full interactive system based on our working groups (Hsieh and Luciani 2005) movement: sensor, database, theory and AI analysis techniques. In parallel with this effort, we are interested in end user studies (similar to our self – portrait study 2) on how movement users classify and respond to these aesthetic visualisation generated outputs of their movement that we have developed here.

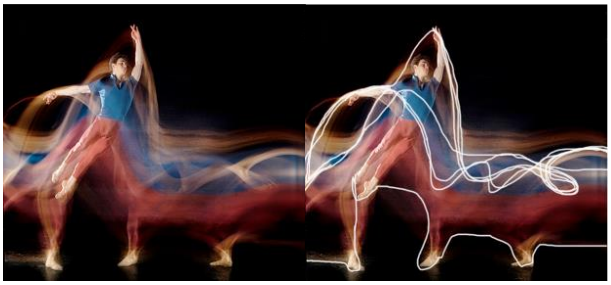

Figure 5A: *Long Exposure Photography © Armand,* ***5B:*** *analysed trace forms.*

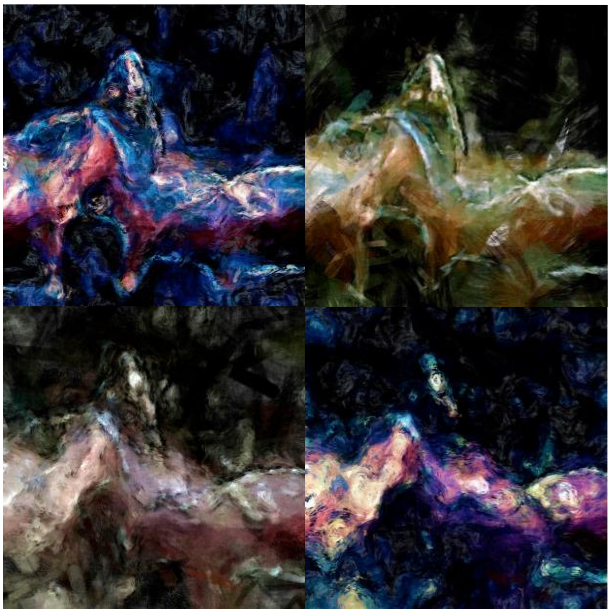

Figure 5C: *Emotional recipes: 06: Sad 07: Afraid p12p12: Calm p12p33: Happy.*

Figure5D: *Dance5 processing in final form with trace forms line painted into the process using ePainterly "happy" recipe.*

Figure 6A: *Original Long Exposure Photography by Armand, Copyright © Jesús Armand,*
6B: *added analysed trace forms.*

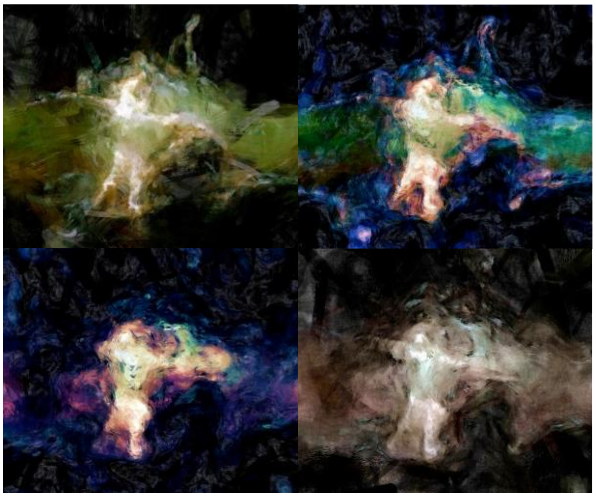

Figure 6C: *Emotional output: 06: Sad 07: Afraid p12p12: Calm p12p33: Happy.*

Figure 6D: *Generated with trace forms line painted into the process using "calm" painter recipe with added trace forms.*

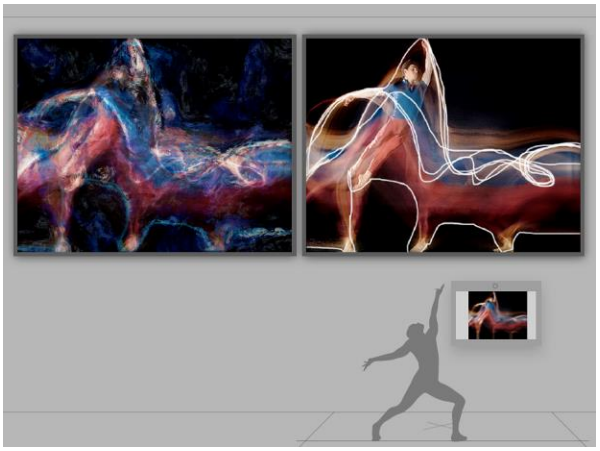

Figure 6E: *Proposed Interactive Installation.*

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