

Body Brush

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Abstract

With the development of an innovative motion capture and analysis system using frontal infra-red illumination, and based on a systematic study of the relations between the human body movement and the visual art language, the Body-Brush turns the human body as a whole into a dynamic brush. The Body-Brush enables humans to interact intuitively with the machine to create a rich variety of visual forms and space.

Introduction

The concept of generating creative work of art through body movement has been an important area explored by a number of artists and researchers in the fields of both arts and technology. By applying the methodology of action painting, Jackson Pollock [5] transformed the body energy and human subconscious into vibrant brushstrokes on his epic size canvas. In a series of performance, Yves Kline used live colour-coated human bodies as brush to paint directly on the canvas. By struggling his body in the mud, Japanese artist, Kazuo Shiraga, created sculptural painting titled “Challenging Mud” [7]. In one of the famous Fluxus event, the Untitled Marching by George Maciunas [8], a group of artists marched across the snowfield and their bodies re-sculpted the environment.

In recent years, researchers made use of the advance of information technology and motion capture system to enable human body to sketch in the virtual space. *Biped*, a new work by choreographer Merce Cunningham, in collaboration with digital artists Paul Kaiser and Shelley Eshkar, translated the dancer’s movement into animated virtual forms which were projected onto the stage screen. *DanceSpace* [9, 10], an interface developed by researchers in the MIT Media Lab, used their self-developed tracking system *Pfinder* (person finder) [11], a real-time computer vision input system, generates computer multicolored graphic trail and music in corresponding to the motion of different parts of the dancer’s body.

These approaches all share two conceptual grounds. (1) The human body movement and gestures are significant human expressions which communicate messages of human inner conditions and human interaction with the outer environment. (2) The message can be communicated in different forms and processes. You may encode the message with paint, mud, snow or digital virtual simulations.

In this paper, we will illustrate a real-time body-driven human-computer interface, the Body-Brush, which is able to capture human motion and transform the motion data into vibrant visual forms. This interface can preserve the 3-D information of body motion. It enables users to interact intuitively with the machine and control the rich visual simulation in synchronization with the body motion.

With a systematic study of the relations between the human body movement and the visual art language, Body-Brush turns the human body as a whole into a dynamic brush. This is

achieved with the development of an immersive computer-vision-based motion analysis system with frontal infrared illumination, and an innovative graphic rendering software that maps the body motion gesture-path-energy to the colour-form-space visual attributes. Since users are not required to wear any specific sensor devices to be recognized by the computer or receive any prior training to use the man-machine interface, Body-Brush enables human to express freely and interact intuitively with the machine.

By controlling the mathematical centres of the body, the motion speed and acceleration, the gestural spatial dimensions, and the body trajectory, the user can create 3D drawing and painting in a virtual 3D canvas. The same set of motion data can also be transformed to simulate a multitude of sculptural forms and architectural spaces. As a result, the sketch in the real space by this body-as-the-brush is transformed into the shaping of the virtual visual space.

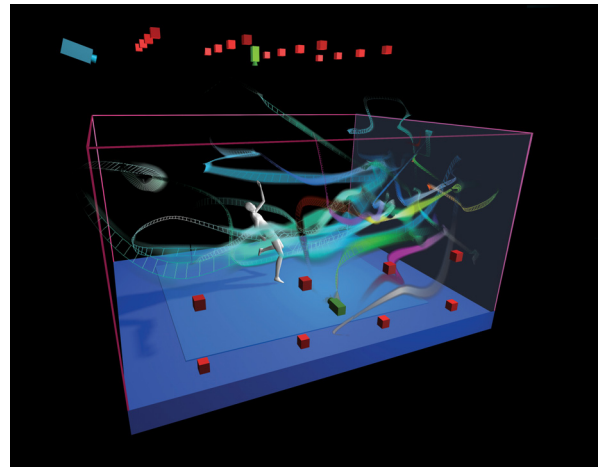


Figure 1. Illustration of the Body-Brush Interface

Frontal Infrared Illumination Motion Capture System

In this work, we have developed an innovative motion capture and analysis system using frontal infra-red illumination to capture human body motion data in the 3D space. With two arrays of frontal infrared illumination, the silhouette image of the well-lit human body can be easily segmented from the background.

The advantages of this system are: (1) the system can extract 3D motion information of human body in a vast space. (2) Since the reflection of infrared depends not on colour, the interface is highly ergonomic and robust as users are not required to wear specific colour clothing or sensor devices. The user can move unobstructed and express freely in the space. (3) The infrared-sensitive camera, filtered incoming light with an infrared-pass-and-visible-blocked filter, is not sensitive to the

change of visible lighting condition. It makes possible to install this system in an environment with changing video projection. Changing studio lighting is also possible if the infrared wavelength can be filtered. (4) This motion capture and analysis system is inexpensive, and portable.

This system treats human body as a single 3D mass. It does not aim at extracting detail information about human gesture. By analyzing the two orthogonal silhouette images, it is possible to extract the position, the body shape, the body dimension, speed, acceleration, and the rate of change of body gesture/motion on the x-y-z planes. In a word, this system sees the motion human body as a whole as a dynamic form of energy.

There are many different techniques to construct a motion capture system involving camera vision, such as chroma-keying [1], background subtraction [11], or rear-light projection [4] / rear-IR-projection [2]. However, each of them has its own limitation. For chroma-keying, a background with evenly distributed colour and illumination is needed. The background subtraction approach requires the colours of the foreground objects to be different from the colour of the background. Computer cannot separate objects from the background if the colours of the objects and the background are the same or similar. Although the rear-light or rear-IR-projection are good at producing sharp silhouette images (black human body on a white background), these two techniques need a lot of space and hard to create a well-lit ground floor for obtaining the top view of the user thus the motion data along the x-y-z-coordinates.

In our approach, background subtraction with frontal IR illumination is used. In order to produce silhouette images with high contrast between the foreground objects and the background, we use two infrared-sensitive black and white cameras (with IR-pass and visible-block filter), and two arrays of IR lamps. IR light can help to segment the user's body from the background easily because the visibility of the human body does not depend on the colour of fabric on the human body. The computer can see the user clearly even he/she is wearing black clothes standing in front of an IR-absorb wall.

Our background (the walls and the floor) is made of IR-absorb material which is invisible to the IR sensitive camera with visible-blocked-and-IR-passed filter. As long as the user's clothes can reflect IR, we can capture images with the user's body (bright) in contrast with the background (dark). These high contrast images reduce the computational complexity for separating the human body from the background based on background subtraction techniques, hence achieving real-time computation requirements.

This system is extremely flexible and easy to setup. Moreover, the capturing area can be extended to an immense space, as long as sufficient infra-red lighting is provided. Resolution of the system can be enhanced by (1) re-structure infra-red lighting setup to diminish shadow area of the body; (2) place more side-view and ceiling-view infrared-sensitive cameras to compensate for the occlusion problem; (3) modify the motion analysis software to adjust to user-specific situation.



(a)



(b)

Figure 2. Imaging System of Body-Brush. (a) Photo taken under visible light showing the clothing colour. (b) Top-view (middle) and side-view (right) captured by the computer through camera views sensitive to infrared illumination only.

System architecture

The video images of the motion body are taken at orthogonal angles by the two infra-red sensitive cameras mounted outside of the 3-D canvas. From the two streams of video images, the user's position within the 3-D canvas space is calculated and the body gestures of the user are extracted and analyzed at video frame rate using a graphic workstation (SGI Octane). A number of numerical measurements relating to the user's gesture are computed and these measurements are translated into various drawing attributes such as colour (hue, value, saturation, and opacity), stroke path and stroke cross-section (for 3D modeling). Finally, these drawing attributes are painted onto a pair of stereo-images and projected back onto the 3-D canvas in synchronization of the user's movement, enabling real-time interaction between the user and the virtual painting and sculpture.

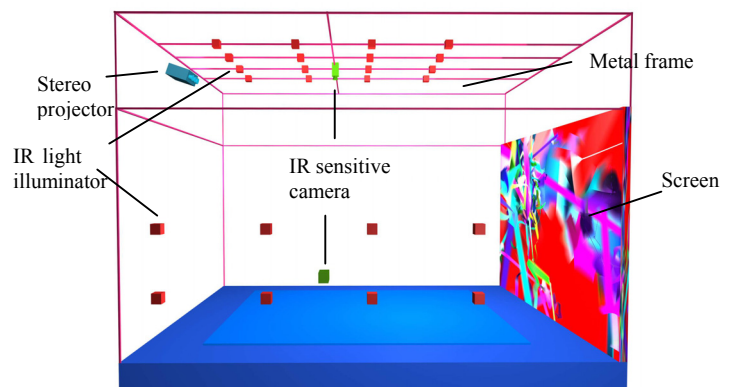


Figure 3. Illustration showing the setup of the Body-Brush Interface

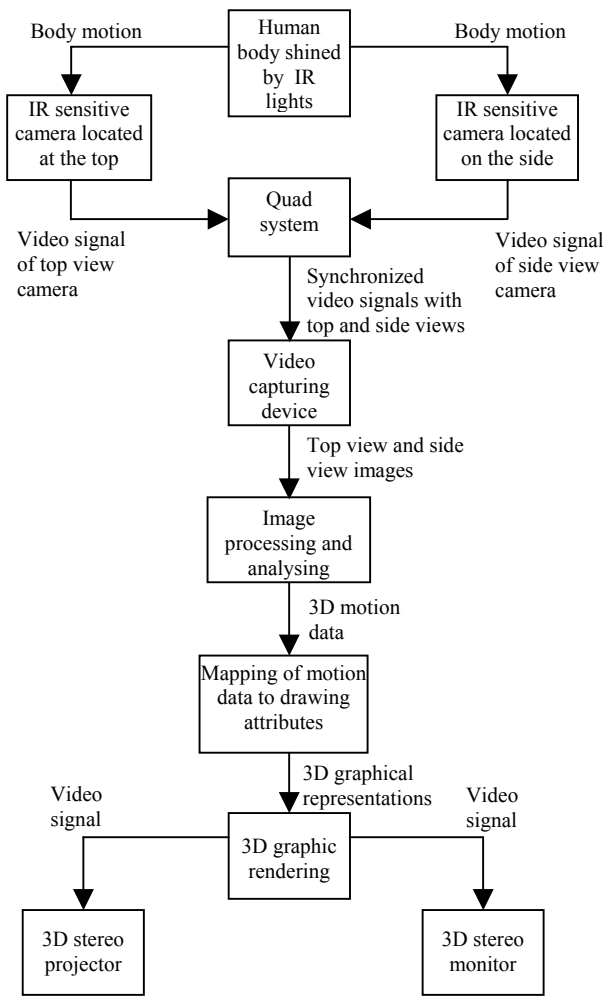


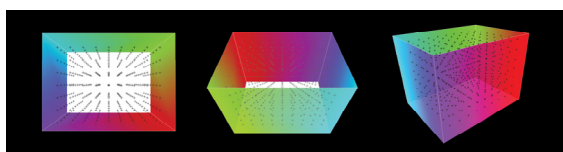
Figure 3. System architecture of the Body-Brush Interface

Visual Aesthetic

The pictorial space activated by the 3D labyrinthine brushstrokes and structural forms, visualized through stereo projection simulation, reflects the intuitive responses and the visual judgements made in the process of man-machine interaction. Since the visualization is in real-time, constantly the user has to make decisions on the forms to be created and the colour to fill them. Of course, the user can choose not to exercise such conscious feedback and let alone the outburst of primal energy and a spread of intuition over the 3D virtual canvas. Thus, by studying the patterns of such numerical information and its corresponding visual significances, it is possible to reconstruct particular cognitive process undertaken by the user.

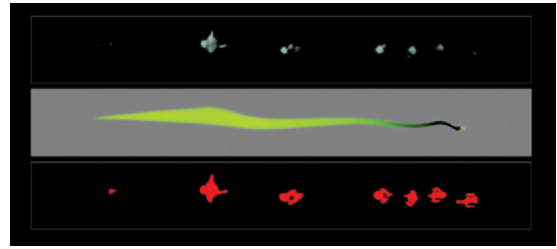
The relationship of the aesthetic visualization and the motion pattern is built upon our visual intuition. Some major mappings are as below:

(1) Colour Hue: When the user enters the outer ring of the space, the body will be attached with invisible color(s). The hues are clearly marked on the floor in 360° and users can choose which hue or a range of hue to be chosen.

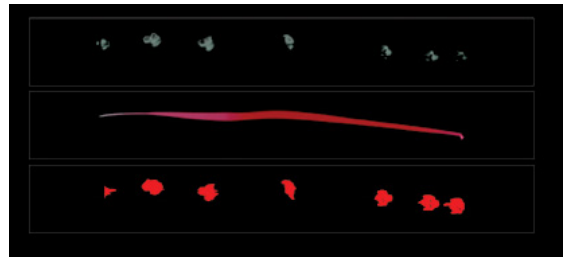


(2) Colour Value: The value is related to the speed of the body motion. The faster speed signifies a lighter sensation of

body. The lighter body will give brighter colour. A slower body motion will give darker colour, and even black.

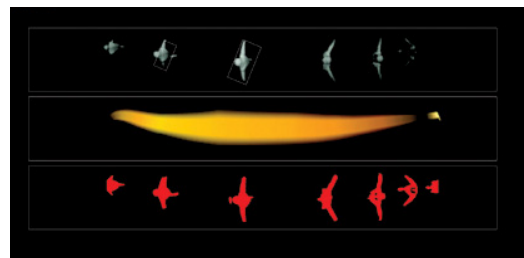


(3) Colour Saturation: The saturation is related to the acceleration of the body motion. When accelerated the body, the body becomes more vibrant. The vibrant body will give more vibrant colour. The acceleration will turn the colour more saturated, while deceleration will turn the colour pale.

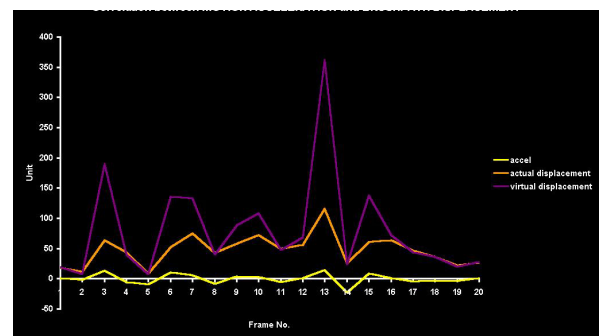


(4) Position: The 3D position of the body-brush is related to the median points of the body as seen from the side-view and the ceiling cameras in orthogonal directions. At time of motion, the changes of height on the farthest left and right positions of the human body are added to the change of mathematical center from the side-view.

(5) Brush Size: The body dimension as seen from the ceiling view will determine the size of the brushstroke.



(6) Virtual Brush: When Jackson Pollock spreaded the paint with a thrust, the paint will not just fall along the path of his hand. In the interface, we also take into consideration the force exerts on the “paint”. If there is acceleration, the 3D path of the brushstroke will be exaggerated accordingly. This “Virtual path” simulates our intuitive conception about painting action.



Graphical User Interface

The Body-Brush GUI (graphical user interface) enables users to define their body-graphic mapping relations, and to walk-through the virtual space and perceive the artwork with different camera positions and composition frames. This viewing pattern, including the camera path, the preference of the visualization environment, and the time lag as well as the camera orientational changes when searching for a new visual destination, can be tracked and documented in the computer data bank.

Using this GUI, users can pre-define the visualization environment of the visual output in synchronization with the body motion. Moreover, a rich variety of post-production features, based on the same set of motion data, are available.

In this GUI, a special feature, Track Camera, can record every detail of the viewing setting and the history of walk-through navigation. That means, the information about how the user defines the visual environment, what visual composition the user chooses, what viewing path the user has come across, and even how much time the user hesitates before finding the next visual destination, all can be tracked and stored in the computer data bank.

By analyzing this information, we can decipher how we construct the meaning of visual signs, and derive certain aspects of human expressive and perceptual patterns. Thus, what the Body-Brush can simulate is not just the virtual graphical space in correspondence with the 3D space of the human body, but also the mental cognitive space activated by the man-machine interaction.

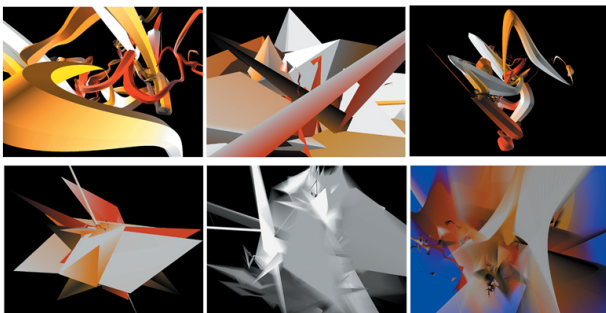


Figure 5. Examples of visual variations generated by one single set of motion data

Future Development

Since its launch in Dec 2001, the Body-Brush has been demonstrated to numerous local and international visitors, such as painters, dancers, scientists, psychologists, businessman, school students, etc. It was particularly interesting to observe that those local young children, at first shy and withdrawn to dance their body in front of other fellow classmates, gradually regained the confidence of their body as well as their creativity, when discovering that they could interact intuitively with Body-Brush to create vibrant colours and forms.

Body-Brush can be applied in diverse domains. Professional visual artist can use this intuitive interface to create rich 2D, 3D or animated visual artworks and polish the visual presentation with the professional GUI. Choreographers and dancer can augment their dance performance by transforming in real-time their dance into rich visual simulation. It can also provide an unique visual experience for audience in museums, galleries, or any public venue. No prior training is needed to for general audience to create vibrant pictures out of their body movement. In some sense, this interface liberates human creativity.

This interface can provide an effective tool and data bank for psychologists, cognitive scientists, and scholars of aesthetics, to study human perception and aesthetics. This interface can also be applied in educational and therapeutic sectors. Psychologists can use this tool to enhance the self-confidence and ability to communicate among psychiatric patients. It can also be an art therapy session for facilitating children to explore the relationship between their body and the visual expressions.

Future development of the Body-Brush will focus on the expansion of the audio-visual feedback dimensions of the interface. A new research, Body-Baton, aiming at transforming body motion data to simulate sound and music, has been gaining its momentum. This project, when combining with the Body-Brush, will enable us to “see picture from music and hear music from picture”, through a systematic mapping of the relationships between the body movement/gesture, graphics, and music.

Furthermore, we are working to stretch beyond the space in which the traditional expressive media has been confined. Perhaps what the traditional media can never achieve is the network collaboration. Since it only requires a minimal amount of body motion data to be transmitted between computers, Body-Brush can enable a seamless interaction between several human and machine units over the computer networks. That means, artists, dancers, and people with different socio-cultural backgrounds and in different countries, can collaborate, via the Internet, to create a rich variety of visual expressions in the same virtual canvas and in real-time. The resulting pictorial rhythm and symbolic diversity will signify an expansion of the geographical space as well as our cultural space.

By transforming the human body into an intuitive yet computable brush, Body-Brush has activated both the subjective space and the objective space unexplored by our conventional visual activities.

References:

- [1] Darrell, T., Maes, P., Blumberg, B., and Pentland, A., “A novel environment for situated vision and behavior”, IEEE Wkshp. for Visual Behaviors (CVPR-94), 1994.
- [2] Davis, J., and Borbick, A., “SIDeshow: A Silhouette-based Interactive Dual-screen Environment”, MIT Media Lab Perceptual Computing Section Technical Report No. 436, MIT, 1997.
- [3] Davis, J., and Borbick, A., ““It/I”: A Theater Play Featuring an Autonomous Computer Graphics Character”, MIT Media Lab Perceptual Computing Section Technical Report No. 455, MIT, 1998.
- [4] Krueger, M., *Artificial reality II*. Addison-Wesley, 1991.
- [5] Landau, E. G., and La Rivere, M., *Jackson Pollock*, 1989.
- [6] Nobuyuki Matsushita and Jun Rekimoto, “HoloWall: designing a finger, hand, body, and object sensitive wall”, *Proceedings of the 10th annual ACM symposium on User interface software and technology*, 1997.
- [7] Schimmel P., “Leap into the Void: Performance and Object”, *Out of Actions – between performance and the object 1949-1979*, pp. 17-120, 1998.
- [8] Smith O. F., “Fluxus: A Brief History and Other Fictions”, *In the Spirit of Fluxus*, pp. 22-37, 1993
- [9] Sparacino F., Wren C., Davenport G., and Pentland A., “Augmented Performance in Dance and Theater”, *International Dance and Technology 99 (IDAT99)*, pp 25-28, 1999.
- [10] Sparacino F., “(Some) computer vision based interfaces for interactive art and entertainment installations”, *INTERFACE Body Boundaries*, 2001.
- [11] Wren C., Azarbajehani A., Darrell T., and Pentland A., “Pfinder: Real-Time Tracking of the Human Body”, *IEEE Transactions on Pattern Analysis and Machine Intelligence* July 1997, vol 19, no 7, pp. 780-785.