SPATIALGENESIS

Event Based Digital Space Making

J. CROTCH, R. MANTHO, M. HORNER
Glasgow School of Art, Scotland

Abstract: Digital technologies and processes have been used to generate architectural form for over two decades, now the recent advances in digital technologies have allowed virtual digital environments to be constructed from physical movement. But can a bridge that connects the physical and virtual realms be developed? Can this, currently arbitrary form making be grounded in human activity and subsequently be integrated in to real time, space and place.

Keywords: digital morphogenesis, spatial, social interaction,

Résumé :

1. Introduction

This research asks how digital morphogenesis can be related to meaning beyond just the creation of form. The research is designed to explore the possibility of connecting the generation of digital form to specific events, and utilising the spatial envelopes of physical movement in the manifestation of real space and real time. Recent examples of current research explores digital form making developed from the digital tracking of activities such as dance, utilising motion capture, (M. Ramsgard Thomsen & J. Mortensen: ESCAPE), while others use genetic programming to evolve 3D shape grammars, (P.S. Coates: UEL). The results are unquestionably intriguing and in some cases quite beautiful, but how relevant is their generation in respect of transferral of these results in to the making of Architectural Space. The questions asked in existing research is how can new form be discovered, or what material and structural possibilities can be derived from form, through these morphological processes. The aim of the overall research project is to complete the loop, *physical - virtual - physical,* and connect these digital processes to the meaning of human activity. The aim is to discover the consequences of generated spatial envelopes that are manipulated through digital morphogenesis and related to specific human action, in the pursuit of possibilities for a digitally generated architecture that is socially engaged. This is not random form finding, wherein architecture tries to imitate biological processes or form, but form finding that is connected to a primary architectural concern, how is the architecture being used by humans.

In this research, human activity is defined as the action of physical movement taking place during the performance of a specific interactive event. Previous studies have used human activity such as dance to produce three-dimensional spatial constructs, and at that point the connection with the activity is lost. We intend to explore more specific activity i.e. one that drives the creation of a three dimensional envelope, and subsequently following development, one in which that activity will be contained within the resultant form. This paper details the development of the process for collecting and digitizing movement information. The paper concludes with speculations subsequent phases of the research.

2. Data Selection and Collection Process

The first phase of the research is to build a body of knowledge regarding ‘Event Based Digital Morphogenesis’, developing techniques for generating forms in relationship to human activity. The research methodology begins with the digital spatial mapping of an activity. But what activity would be appropriate? Several possibilities were considered, and preliminary recordings of these were made, viewed and critiqued prior to our selection. The selection of this was based on many factors, but primarily we wished to use a very ‘everyday and ordinary’ human activity. We believed that repetition of certain actions was important, as recognition of pattern was going to be an element that would be examined in the following stages of the experiment. We were aware that even though random action would occur these movements would be held in a context of more standard movement patterns. Our final decision was made following careful reflection on the potential data that would be generated. Without wishing to pre-empt our results a certain degree of speculation was necessary in this process. The team finally settled on the activity of preparing food and eating. It was also agreed that the introduction of more that one figure would enrich the data. Two figures performing the selected activity would provide social engagement and further ground the experiment in reality.

2.1. Set design

The next step was the creation of *the physical*; a skeletal stage set had to be created that would frame the performance of the activity. There were several factors that had to be taken into account in respect of the ‘set’ in order to allow filming of all the movements to be recorded clearly and equally. Location of a space big enough to accommodate the room set and the cameras was found, but more importantly one that also had controllable lighting conditions. The space selected a now disused gallery space, fulfilled both the space requirements and was naturally lit from diffused top lighting. The issues with lighting were initially recognised, but never fully resolved. It was important to try and eliminate shadow, as this would be picked up in the film analysis and form making and subsequently distort the results. While the chosen space did reduce some of the problems, lessons from subsequent phases revealed that the lighting conditions were not ideal.

Designs and drawing of the proposed ‘set’ were made. We were then able to discuss and agree on both the practical issues; for example camera positions and set lay; along side those of a more creative elements i.e. the choreography of the activity and, more specifically the movements that would be made by both figures. Minor adjustments to the design were made and construction of the frame took place.

2.2. Data collection

The mode for collection of information raised further questions regarding the type of data we wished to be produce as a result of the recording of the activity. The target was to produce a series of envelopes reflecting the actor’s occupancy of space over time. It was anticipated that these envelopes would reveal the actors occupancy of any slice of 2d, 3d or 4d space. Having considered the alternatives along side our particular expectations, the team conclusively agreed that ‘motion capture’ was not appropriate in terms of the spatial envelope that we wished to create. Motion capture produces a skeletal frame. The aim of this research was to capture a three dimensional space with a continuous skin, as in the manner reported by (Tangkuampien, T.; Tat-Jun Chin), where a marker-less, non-invasive form of motion capture was sought. Following much discussion and debate the team agreed that a ‘low tech’ recording method would give us the material most suited for our requirements. The plan was to install the ‘set’ or kitchen frame and accurately position cameras at the four corners of the set, withdrawn sufficiently to allow a wide enough view of the ‘kitchen’, and giving adequate overlap of views to ensure all movement could be detected from at least three cameras at any time. The filming was reordered on four high quality DV cameras set at a height of 3 meters from ground level and located in the agreed locations (fig. 1). Once in situation their exact location was measured manually and recorded.

Figure 1. Camera set up

The design and making of the set was critical. All was contained within a 3-meter cube, located with a 3meter square taped on the floor. This taping would play a part in the future analysis of the material in order to correct the intrinsic camera distortion. We were aware that it had to be as skeletal as possible as any solid object or surfaces would result in movement patterns being obscured (fig. 2). Minimal props were also included to allow the 'mime' to take place with as much accuracy as possible.

Figure 2. The 'set'

2.3. Conclusions regarding data collection

Following the filming it has been have realised that despite the care taken in the design of the set, decisions made have had an impact on the material collected, and have subsequently created more work to allow the spatial/movement information to be as clean and as accurate as possible. One such problem arose with the white worktops, despite care with the lighting, shadows were cast on these surfaces, and became part of the recordings, and had to be eliminated from the data. We would conclude that the design of the set is more critical that we had at first envisaged, dark tones, more skeletal formwork and fewer props would have provided a 'cleaner' set of digital results, with less work required to ‘de contaminate’. This knowledge will be useful if we are to repeat the experiment in a different format.

The team designed and wrote a script for the choreography of the activity. This was rehearsed rigorously in order to create a comfortable performance, and one that could be repeated reasonably accurately with ease (fig. 3). We decide to re-enact ‘making and eating breakfast’ with two performers acting out this activity. It was our aim to ‘perform’ as naturally as possible, this was important in terms of our desire to utilise real activity performing specific event in real time.

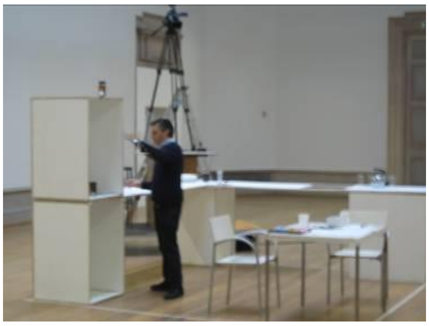

Figure 3. Rehearsal of the activity

Following the design, set up and rehearsal of our set and activity, the filming process was a reasonably rapid one. Five live sequences were filmed during a one-day session (August 2008), with each sequence of about 11minutes in length. Standard filming procedures were adopted to provide a rigorous process.

3. Data Processing

The film recorded the interaction between the two bodies mapped with video recording. The next stage transferred the physical into *the digital*, the goal being to produce a ‘spatial envelope’ of the activity over the full duration of the event. Because the goal was to achieve a spatial map as opposed to a motion study, a camera/computation approach was preferred to a motion tracked skeletons.

From each of the 4 cameras, a 2-D image is derived for each actor at one moment in time. Using these 2-D images a cone of space is generated for each camera, by intersecting these cones a 3-D shape for each actor is constructed for each frame. By placing the shapes for both actors together a 3-D ‘spatial envelope’ of a single moment is generated. Once these individual moments are merged, a ‘spatial envelope’ of the activity is produced. This process requires a robust and translatable outcome at each step.

3.1. Video transposing

The first step in the translation was to use an Avid console to translate the digital video format into 4 individual 56 minute movies. From these 4 films, 4 sets of 1500 TIFFs, representing a typical minute's filming, were extracted for study. Various processes were tried in ImageMagick to empty the background information to derive 2-D shapes of the human actors. The goal was to convert these TIFF images from the colour TIFF. format into a white on black silhouette, 2 colour PNG. file. This process of isolating the human figure had two primary goals: each step needed to produce a digital format that would provide multiple options for the succeeding steps, while also allowing the process to be automated for processing the 4 complete films.

3.2. Figure extraction

The first test was to use ImageMagick to segment the images of the actors from the empty background, this function having been written by a member of the team (fig. 4).

Figure 4. Empty Set – Background

A sequence of carefully tuned and threshold RGB separation processes were tried (fig.5).

Figure 5. Single Frame with Actor

These simple techniques isolate the human actors from the background of the image, but shadows were still evident. Further use of a hue-discrimination filter removed most of the shadows cast on the white surfaces (Fig.6). These various filters were combined to produce a single white on black silhouette of the human actor with any objects moved by him and hence incorporated into his spatial occupancy.

Figure 6. White on Black Silhouette

A minutes worth of this conversion process for one camera (1500 images) takes approximately 90 minutes.

3.3. Curve construction

The next step was to experiment with Autotrace to produce a set of closed curves from the white on black silhouettes. Firstly the PNG. files were converted to PBM. files. These files were then used to make a set of closed curves. The first attempts resulted in some problematic curves, as some of them crossed over which created complex geometry. After correcting for these problems, the files were then imported into Maya to begin the construction of 3-D shapes.

3.4. Camera set up in digital space

A manual scene of the four cameras was constructed in Maya to confirm that Maya could accurately map the space of the film. It was also determined that the distortion of the cameras could be corrected or, within the accuracy of the process, effectively ignored (fig.7).

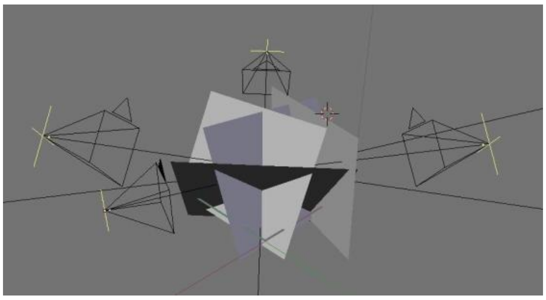

Figure 7. Camera Set up in Maya

3.5. Extrusion of curves into forms

The curves were aligned with the image planes for each camera, creating profiles of the camera’s view of the human bodies from the film. These profiles are then extruded along the camera’s eye-lines (fig.8).

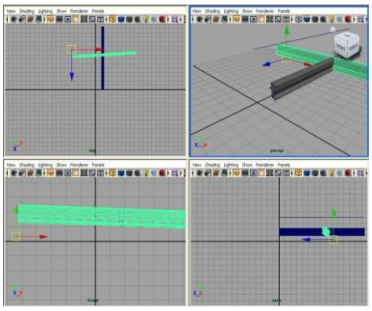

Figure 7. Setting up the extracted curves in Maya

This creates a cone representing the camera’s view of the spatial occupancy of the actors (fig.8).

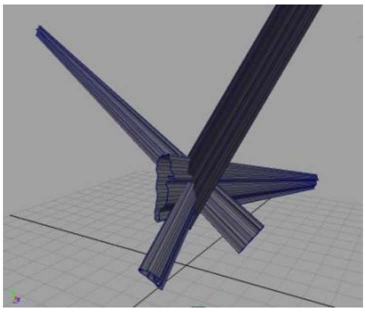

Figure 8. ‘Cones of occupation’ in Maya

3.6. Intersection of forms to construct envelope

Intersection operators are used on each camera's cone to cut down the volumes of the other cameras. This produces a minimal set of solid shapes, when the shapes from all four cameras are combined a unique 'spatial envelope' of the actors is constructed (fig.9).

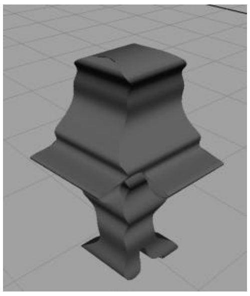

Figure 9. 'The intersection of 'cones of occupation during one moment' in Maya

These individual 'spatial envelopes' are then combined to create a complete 'spatial envelope' of the event Each separate stage has been scripted and could be done using other programs or could be automated differently.

4. Pattern Analysis

This envelope has been analysed to determine the patterns of spatial change. As the envelope fluctuates over the duration of the event, patterns of density and thinness have emerged. Areas of contained activity become thick with layers of repetitive motion, while the movement between locations are stretched. A planametric analysis was done to confirm these 3-D patterns.

5. Algorithmic Processing

The next phase of the project is to develop algorithmic expressions of these patterns. These algorithms will be utilised to manipulate the original spatial envelope. The number of iterations used in this algorithmic process is based on the structure and patterns of the initial activity. Each phase of activity lasts for approximately 3 1/2 minutes. Three distinct phases of the activity were observed, preparation, consumption and clean up. Each phase demonstrates different motion patterns and varied rates of repetition of the iterative movements. These phases each result in an algorithm, generating an algorithmic process for the transformation of the 'spatial envelope' of the activity. The patterns of movement in each phase determine the number of iterations for each algorithm. The 'preparation' phase algorithmic process will be run 6 times, which is based on the movement of each actor from the table to the various stations in the 'kitchen'. The 'consumption' phase algorithm will be used 20 times, to reflect the repetition of the actors arm movements. The 'clean up' algorithm will be run 8 times, again derived from the movement between table and kitchen stations.

Following the extraction of these repeated movements and analysis, algorithmic formulae will be constructed. The algorithms will then be fed back into the spatial envelope data, and will be run to produce a transformation of the original spatial envelope.

This algorithmically transformed space will then be inhabited with the digital spatial map of the activity to test the interaction between the algorithmic influenced space with the spatial map of the activity. The algorithmically manipulated space will be assessed as architectural space, judges both for its appropriateness and for its architectural qualities. These complex digitally generated environments will then be transposed back to *the physical*, to produce a manifestation of space driven directly by the activity, which it is designed to contain. A new *'part physical, part virtual'* architecture is born, an architecture which is formed by physical activity and which explores spaces virtually with digital tools and processes.

6. Further Development of the Research

The next stage of the research will explore ways in which the form-generated space could be developed to interact with users and a feedback loop between human activity and digital space can be established. Once a methodology has been established to create digital envelopes directly from specific activities; with applied algorithms written in response to the space produced; the possibilities are endless, as are the activities that could be utilised to produce these new spaces. A variety of researchers have been working on creating systems in which human actors interact with the digital, seeking to find ways in which human agency can utilize technology to shape experience (Fruhwirth, Hirschberg & Zedlachar; no_Lab,TU Gratz). This research pursues similar concepts, while also exploring how architectural space develops when the user's interaction influences successive generations of architectural enclosure. The research is speculative and proposes that this digitally generated space, tied to human activity can ground the new digital methodologies in the historical tradition of architecture.

The project would utilize a physical version of the architectural space developed using the event based digital morphogenesis process. Questions may arise for example '*as the architectural enclosure evolves, how does the user's behaviour change in response to the emergent architecture?'* and *'How can an architecture generated from human activity, which changes in relation to use influence future activity, be developed?'* This research explores the possibility of an architecture, which is both dynamic and collaborative with its users, learning and teaching in a dialogue with events and their participants.

7. Conclusion

Current digital morphogenesis is concerned with generation of form; this research tests the possibility of connecting this generated form with specific activity. The criteria for judging the generated space is the relevance of this space to the specific activity that it contains and from which it was originally derived. The camera computation method of recording the movement associated with specific activity has been confirmed as the appropriate methodology, as it results in 3D spatial maps as apposed to linear tracking diagrams of motion. The process creates envelopes from which 3D spatial patterns are isolated and utilised to generate the algorithmic formulae used in the transformation of the activity based spatial envelope. This re-application of these algorithms to the spatial envelope generates unique spatial constructs directly related to the initial human activities, not based on abstract principles of spatial requirements. These new spaces open potential possibilities of an architecture whose relevance is in its direct relationship with meaningful social activity. Potentially the feedback loop between user and architecture could result in an architectural space that has shed cultural conventions and is a direct response to human spatial needs. The value of such architecture; where the relationship between the space and the activity which determines it, and which it subsequently contains; seem obvious.

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