From Costuming and Dancing Sculptures to Architecture
The Corporeal and Computational in Design and Fabrication of Lightweight Mobile Structures

Vernelle A. A. Noel
The Pennsylvania State University
vernelle@alum.mit.edu

Abstract. This paper describes a new approach to designing and fabricating costuming and dancing sculptures and the potential application of this system at the architectural scale. I present a novel design system based on the movement, form, and spatial relation of characters and dancing sculptures in the Trinidad Carnival. I also present a system that produces lightweight mobile structures from 3D printed connections, lightweight rods, and textile. Through a detailed case study, a new dancing sculpture is designed, and a full-scale lightweight mobile structure at the architectural scale is fabricated. Fabrication of the lightweight structure is achieved using Digital Crafting and Crafting Fabrication approaches to wire-bending, which includes the early development of a digital fabrication program for rod elements. This work has potential implications for costuming and dancing sculptures; architecture; computational design; and craft practices.

Keywords: Lightweight Architectural Structures, Trinidad Carnival, Corporeal, Dancing Sculptures, Fabrication

1 Introduction

This paper describes a design and production system informed by characters and dancing sculptures from the Trinidad Carnival (carnival). Dancing sculptures are large three-dimensional structures that are supported and danced by the body, and that communicate human energy. This project’s design system uses parameters developed from analyzing existing costumes in the carnival, and their relation to the body, in the design and generation of three-dimensional form. The production system manufactures a lightweight mobile structure from techniques coming out of a traditional craft and computational processes. Specifically, this research demonstrates how a computational approach to design might (1) use the body and its movement to generate form and space; and (2) reframe the design of dancing sculptures for potential applications in architecture. This research builds on other approaches to exploring relationships between the body in motion and space, as design parameters are developed from analyzing the body and its movements in relation to costuming and dancing sculptures. These parameters are used to generate a new design for a
dancing sculpture, and possibly architectural form. When it comes to computational approaches to digitally fabricating architectural structures, this work uses a production system based on wire-bending, a traditional craft practice for making costumes and dancing sculptures in the Trinidad Carnival. To illustrate these computational approaches, the reader is taken through the design of a dancing sculpture, and the construction of a lightweight architectural structure.

This paper begins with a brief introduction to costuming and characters in the Trinidad Carnival, and the craft of wire-bending. It continues with a review of previous works on the body in three-dimensional space and form. Then, it discusses how computational approaches are being employed to reframe traditional craft practices in design. After the introduction and background, we describe the design process for a dancing sculpture we name, “The Sail”, then present the production system that takes this structure to the architectural scale. Finally, we present and discuss the work’s contributions to design.

2 Background

2.1 Costuming in the Trinidad Carnival

French planters introduced Carnival to Trinidad in the 1780’s, but it was reinvented by slaves in the 1830s (for a detailed discussion on the Trinidad Carnival see (Hill, 1972; H. U. Liverpool, 1998; H. Liverpool, 2001; Noel, 2015; Brown, 1990; Lee, 1991; Riggio, 2004; Tull, 2005; Ryan and Institute of Social and Economic Research, 1991). Costuming in the carnival portrays its origin, historical events, its people’s creativity, struggles, and victories as they perform, gesture, and move in various ways (Fig. 1). The Negre Jardin, which first showed up in the carnival in 1834 (Hill, 1985), was originally performed by freed slaves and planters “in satiric mockery of their former enslavement and by plantation owners as derisive imitation of the enslaved (Martin 1998).” The Moko Jumbie or stilt-dancer, like those formerly enslaved, has its roots in West Africa. It first appeared in the carnival in 1895, and dances a jig on stilts as high as 10-15 feet (Crowley, 1956b; Nicholls, 1999). It is “the spirit of Moko, the Orisha (god) of fate and retribution (Martin 1998).” Performers of The Bat, which appeared in the carnival in 1899, wear a black or brown skintight suit with wings attached to the feet and shoulders (Crowley, 1956b; Hill, 1985).
Large dancing sculptures in the carnival are called Kings and Queens (Fig. 2). They may depict history, current events, fantasy, or traditional characters, to name a few. Performers are “an integral part of the costume and must wear and/ or carry the costume,” unlike floats that are “pushed, pulled or driven” independent of the performer (National Carnival Bands Association of Trinidad and Tobago 2017). These sculptures sometimes measure 20 feet in width and/ or height. One of the main carnival crafts employed in constructing these sculptures is wire-bending. Wire-bending is a “specialized art, combining elements of structural engineering, architecture, and sculpture” to create two-dimensional (2D) and three dimensional forms” (“Lewicito ‘Cito’ Velasquez”, 2015). In this craft, wire and other thin, flexible strands of material are bent with hand tools to create 2D and 3D structures (for a detailed discussion on wire-bending in the Trinidad Carnival, see Noel 2015). The next section presents background on movement of the body and its relation to 3D space.
Fig. 1. M. Prior engraving, carnival parade, Port of Spain, 1888. From Illustrated London News, photograph by Gordon Means.

Fig. 2. Dancing Sculpture in the Trinidad Carnival (2010). Photo by author.

2.2 The Body and Space

Movement of the body, its relation to 3D space and form, and its documentation has occurred primarily in the field of dance. Oskar Schlemmer, painter and sculptor at the Bauhaus, developed a complex notation system to plan and record the movements of performances. This notation described linear paths of motion and forward movements of dancers. Schlemmer’s paintings delineated the two-dimensional elements of space (Fig. 3), while the 3D nature of the theatre provided a place to experience space (Goldberg, 1979). He designed costumes that materialized transformations of the human figure through abstraction via: the form of the body surrounded by cubic space; the body in relation to space; the law of motion of the body in space; and the metaphysical forms of expression of the body (Lahusen, 1986).

Fig. 3. Oskar Schlemmer’s drawing from Mensch und Kunstfigur, 1925 (left), and drawing for “Figure in Space with Plane Geometry and Spatial Delineations”, 1927 (right).
Choreographer Rudolf Laban also developed a notation system for documenting and describing human movement. One of his theories, choreutics\(^1\), had an architectural element to it as it dealt with the sculptural quality of movement emerging from the moving body (Fig. 4) (Davies, 2006; Sutil, 2013; Maletic, 1987). Laban used three-dimensional form to better understand and visualize human movement in space.

Interaction designer and trained classical dancer, Ashwini Asokan, and mechanical engineer Jonathan Cagan (2005) developed a movement grammar using a shape vocabulary created from studying the movement of people involved in coffee drinking and making. They then used this grammar to design coffee tumblers and cups. Architects, Ferreira et al. (2011), used shape grammars to describe the body in motion and space; codified dynamics of the body with these shape rules; then developed a simulation tool based on those rules to generate a choreography. They hoped to use this program to generate architectural space enriched by corporeal experience. Mas\(^2\) man and carnival designer, Peter Minshall, began his study of “kinetic and expressive” costuming in carnival in the 1970s (Gulick, 2000). One costume, The Bat, was the foundation on which he developed a variety of new structural forms he calls dancing mobiles (Fig. 5). These dancing mobiles all start from the form and energy of the performer, achieving new ways of communicating energy up and out into the mas structure (Gulick, 2000; Minshall, 1990; Minshall, 2000).

---

\(^1\) Choreutics is “the study of harmonious movement sequences and their spatial and expressive relationships” (Maletic 1987).

\(^2\) Mas is the Trinidadian word for masquerade. Some people prefer to use the word "mas" instead of Carnival. Mas is part of the triumvirate of calypso, pan, and mas (Martin 1998).
Choreographer Rudolf Laban also developed a notation system for documenting and describing human movement. One of his theories, choreutics, had an architectural element to it as it dealt with the sculptural quality of movement emerging from the moving body (Fig. 4) (Davies, 2006; Sutil, 2013; Maletic, 1987). Laban used three-dimensional form to better understand and visualize human movement in space.

Fig. 4. Harmonies of movement of 12 basic directions of swings in ballet by Laban according to right-left (left), and forward-back (right) symmetry of the body.

Interaction designer and trained classical dancer, Ashwini Asokan, and mechanical engineer Jonathan Cagan (2005) developed a movement grammar using a shape vocabulary created from studying the movement of people involved in coffee drinking and making. They then used this grammar to design coffee tumblers and cups. Architects, Ferreira et al. (2011), used shape grammars to describe the body in motion and space; codified dynamics of the body with these shape rules; then developed a simulation tool based on those rules to generate a choreography. They hoped to use this program to generate architectural space enriched by corporeal experience. Masman and carnival designer, Peter Minshall, began his study of "kinetic and expressive" costuming in carnival in the 1970s (Gulick, 2000). One costume, The Bat, was the foundation on which he developed a variety of new structural forms he calls dancing mobiles (Fig. 5). These dancing mobiles all start from the form and energy of the performer, achieving new ways of communicating energy up and out into the mas structure (Gulick, 2000; Minshall, 1990; Minshall, 2000).

Choreutics is "the study of harmonious movement sequences and their spatial and expressive relationships" (Maletic 1987).

Mas is the Trinidadian word for masquerade. Some people prefer to use the word "mas" instead of Carnival. Mas is part of the triumvirate of calypso, pan, and mas (Martin 1998).

This project situates itself amidst these works on the body, space, and form, by using the body and costuming to generate computational rules to design dancing sculptures. For Schlemmer, the 3D nature of the theatre provided a place to experience space. In this work, we envision the 3D nature of these dancing sculptures and their relation to the body as a place for one to experience space, and become aware of their own movements and actions since “we remain unaware of most of our actions, unless an [...] event [such as moving in relation with a dancing sculpture] brings them into consciousness” (Jeannerod, 2006; Sheets-Johnstone 2011, 2015, 2009). Building on the work of Asokan and Cagan, and Ferriera et. al., we analyze the dancing action, geometry, and spatial relations of carnival characters to design a new dancing sculpture, and explore its potential in generating architectural form. Like Minshall studied The Bat to develop his dancing mobiles, this work too develops a new dancing sculpture by analyzing and synthesizing traditional and contemporary characters and dancing sculptures from the carnival. To do this we use the body and costuming to generate computational rules to create 3D form for dancing sculptures and architecture. The following section discusses how computational approaches are being employed to reframe traditional craft practices.

2.3 Craft and Computation

Research in computation and technology in traditional craft cultures include merging digital tools with jewelry craft (Jacobs and Zoran, 2015), digital ceramic mold-making (Muslimin, 2013), hybrid basketry (Zoran, 2013), the development of a digital milling carving device (Zoran and Paradiso 2012, 2013), digital steam bending (Schulte et al., 2014), using craft as a site for technical appropriation (Rosner and Ryokai, 2009), critical making (Ratto, 2011), reconceptualizing craft to create architectural components (Muslimin, 2014), and a computational approach to the traditional craft of wire-bending (Noel, 2015, 2016a; TEDx Talks, 2016). Muslimin tested the use of digital modelling and CNC routers in the fabrication of negative molds for ceramics, reconfiguring fabrication devices based on digital methods of transformation. In his work on hybrid basketry, Zoran merged the digital and the
traditional by using hand weaving techniques to lace reeds through 3D printed structures he digitally designed and fabricated. In another work, he develops a handheld digital milling device, that carves digital 3D objects out of physical material. Schulte et. al. reclaimed the traditional, historical craft of steam bending through digital design, form generation, and bending. Muslimin (2014) reconceptualized elements of traditional weaving to create architectural components. Through the creation of “woven bricks” and a woven timber installation he proposed architectural applications for expansion of the weaving language. Noel (2016a, 2016b) developed the Bailey-Derek Grammar to describe wire-bending from Trinidad and Tobago. She also developed three novel approaches – Digital Crafting, Computational Crafting, and Crafting Fabrication – to integrating computation and digital technology in wire-bending for the design, fabrication, and assembly of lightweight wireframed artifacts. Like Schulte et. al. and Muslimin, this work reclaims a traditional craft, but also reframes it in a new way using digital approaches to designing and connecting rod elements. The next section describes the steps involved in designing and constructing a lightweight mobile structure called, The Sail.

3 Case Study: The Sail

This section describes and illustrates the steps involved in taking a computational approach to designing a dancing sculpture. The six steps shown in Fig. 6 include a design stage which describes the steps in the computational design system, and the production system employed to construct a form at the architectural scale. The processes involve:

Design:

1. Analyzing a corpus of existing costumes/ dancing sculptures;
2. Developing design parameters from that analysis;
3. Parametric modelling of existing dancing sculptures;
4. Computational design of new forms based on parameters;
   a) For application in dancing sculptures,
   b) For form at the architectural scale, and

Production:

5. Fabrication; and
6. Assembly.
Schulte et al. reclaimed the traditional, historical craft of steam bending through digital design, form generation, and bending. Muslimin (2014) reconceptualized elements of traditional weaving to create architectural components. Through the creation of "woven bricks" and a woven timber installation he proposed architectural applications for expansion of the weaving language. Noel (2016a, 2016b) developed the Bailey-Derek Grammar to describe wire-bending from Trinidad and Tobago. She also developed three novel approaches—Digital Crafting, Computational Crafting, and Crafting Fabrication—to integrating computation and digital technology in wire-bending for the design, fabrication, and assembly of lightweight wireframed artifacts. Like Schulte et al. and Muslimin, this work reclaims a traditional craft, but also reframes it in a new way using digital approaches to designing and connecting rod elements. The next section describes the steps involved in designing and constructing a lightweight mobile structure called, The Sail.

3.1 Computational Design System

3.1.1 Step 1: Analysis of existing costumes/dancing sculptures

Characters selected for analysis were chosen based on their dynamic movements, and positions as traditional characters in carnival (Crowley, 1956b; Minshall, 1990). Some of these characters have existed since the 1890s, while others appeared in the 1980s. Nine of them were traditional carnival characters, while five of them were dancing sculptures designed by Minshall. I analyzed literature, video, and images describing the design and movement of the characters, some of which are shown in Fig. 7 - the Bat, the Imp, Midnight Robber, Moko Jumbie, Moon of Kaiso, Fancy Indian Chief, and Tic Tac Toe Down de River (Crowley, 1956b, 1956a; Procope, 1956; Hill, 1985; Minshall, 1990; Noel, 2016c). The wingspread of the Bat (Fig. 7A) is about 12-15 feet, and its movement is such that the dancing actions of the performer’s arms, body, and feet are transmitted throughout the structure (Gulick, 2000; Minshall, 1990). The Imp’s (Fig. 7B) movements spring from the shoulders with short, sharp, continuous darts of the upper body (Procope, 1956; Minshall, 1990). The Moko Jumbie’s (Fig. 7E) movements originates in the legs and feet, dancing a jig (Crowley, 1956b, 1956a; Noel, 2016c).

By wearing the costumes, and moving as these characters shown in Fig. 7, the body discovers not only aspects of the surrounding world such as ground, gravity, and resistance, but also aspects of themselves. This includes the positions, movements, and work of undergone by body parts, limbs, bones, and muscles to place and move.
the dancing sculptures, discovering the possibilities of their bodies along the way (Sheets-Johnstone 2009).

A. The Bat (1899) (Stegassy 1998) Photo by Jeffrey Chock.


C. Midnight Robber (1919) (Crowley 1956b) Drawing by Carlisle Chang.


E. Moko Jumbie (1895) (Martin 1998) Photo by Carol Martin.

F. Fancy Indian Chief (Crowley 1956b) Drawing by Carlisle Chang.


Fig. 7. Seven (7) of 14 existing dancing sculptures analyzed
3.1.2 Step 2: Develop design parameters from analysis

Parameters were developed by analyzing movements, geometry, and spatial relations of costuming and the body in space, to generate new designs. Parameters include:

1. Means of support by the body/structure (B\text{SUP\text{PORT}});
2. Means of extending space around the body (B\text{SPACE EXTENSION});
3. The movement of dancing sculpture (B\text{MOVEMENT});
4. Location(s) of attachments to the body (B\text{ATTACHMENT LOCATION});
5. Spatial relation of dancing sculpture to the body (B\text{SPATIAL RELATION}); and
6. Geometry in design of dancing sculptures (B\text{GEOMETRY}).

3.1.3 Step 3: Parametric modelling of existing dancing sculptures

The third step involved using the body as the “site” for parametrically modelling existing designs (Noel 2016c). Parametric designs of eight existing dancing sculptures were digitally described and modelled on an abstracted human figure. Fig. 8 shows digital parametric models of four existing dancing sculptures: The Bat, the Imp, the Moko Jumbie, and Moon of the Kaiso.

![Parametric models](image)

Fig. 8. Parametric models of existing costumes and dancing sculptures (a) the Bat; (b) the Imp; (c) Moko Jumbie, and (d) Moon of the Kaiso.

3.1.4 Step 4: Computational Design of new dancing sculpture

After describing and modelling existing dancing sculptures, parameters used to create a new design included movement, geometry, support, extension, and spatial relation. The main support of the dancing sculpture would be the performer’s back, and it would be animated by moving the shoulders, and feet, like the Imp, Moko Jumbie, and Tic Tac Toe (Figs. 7B, E, G). It employs design elements reminiscent of the cape of the Midnight Robber (Fig. 7C), and Tic Tac Toe to enclose 3D space around the body, and have a vertical spatial extension like the Moko Jumbie. The parameters used to design The Sail in Fig. 9 are:

1. Support by the body/structure (B\text{SUP\text{PORT}}) = The back
2. Extension of space around the body (BSPACE EXTENSION) = Lines and planes (e.g. Moko Jumbie and Midnight Robber)
3. Movement (BMOVEMENT) = Feet and shoulders (e.g. Moko Jumbie, Tic Tac Toe, Imp)
4. Location(s) of attachments to the body (BATTACHMENT LOCATION) = Shoulders, feet, and back
5. Spatial relation to body (BSPATIAL RELATION) = Above, sides, left, right, symmetrical
6. Geometry (BGEOMETRY) = Arcs, lines, curves, triangles

Fig. 9. Form generated using parameters in step 4. Front elevation (left), perspective view (right)

Additional parameters used to develop the form of “The Sail” in Fig. 10 are:
1. The location of control points in relation to the body (FCONTROL POINTS);
2. Height of the form (FHEIGHT);
3. Height of the form in relation to the body (FHEIGHT IN REL TO BODY);
   a. Height of form in front the body (HA);
   b. Height behind the body (HB);
4. Depth of form (FDEPTH);
5. Width of form (FWIDTH), and
6. Surface/ Structural expression of form (FEXPRESSION);
   a. U-divisions for structure (EU);
   b. V-divisions (EV).

Fig. 10. Plan of The Sail with parameters width (FWIDTH), and depth (FDEPTH) of the structure). Front view with height (FHEIGHT) of the structure, and its height above the human body (FHEIGHT IN REL TO BODY) (right). Explorations of the density and expression of structure and skin shown on forms on the left.
The design system described above generated a new design for a dancing sculpture, i.e. a large 3D sculpture that is supported by the body, communicates human energy, and makes us aware of our bodies, their actions, and the surrounding world. The next step was fabricating “The Sail.” Due to limited resources, we decided to build one side of “The Sail,” and explore its architectural possibilities by increasing its scale, and using a lightweight construction system built on traditional wire-bending principles. The next section presents our approach to constructing a lightweight architectural structure.

3.2 Lightweight Architectural Structure

Like dancing sculptures in carnival, this structure is made from lightweight rods and materials, and the construction technique used is based on a craft at the foundation of the carnival, wire-bending. Like Schulte et. al., and Muslimin, we are reframing this traditional craft by using digital approaches to designing and connecting rod elements. Like Muslimin, we are proposing architectural applications and expanding the language of wire-bending by creating components that can be employed in the production of architectural structures. We acknowledge that this is a first step and the beginning of future research and development.

Fig. 11. Plan view (a), and side elevation (b), and perspective views (c, d) of potential architectural form.
The architectural structure shown in Fig. 11 measures 6’-2” in height, 7’-6” in width, and 5’-0” in depth (for a video orbiting the structure see Noel 2017b). The materials and components for construction would be lightweight and modular: fiberglass rods, plastic 3D printed connections, masking tape, and double-sided neoprene fabric for the skin. After designing the structure according to the desired parameters, size, and geometry of the structure and skin, Digital Crafting and Crafting Fabrication approaches were taken to construct the form (for a more detailed description of these approaches to crafting see Noel 2016a).

3.2.1 Steps 5: Fabrication

Digital Crafting of the Structure

Digital Crafting is the “reinterpretation of a traditional craft using digital processes and technologies [...]. This includes employing digital programs for design, optimization, and automation, [including] CNC machines such as 3D printers or CNC routers for digital fabrication (Noel 2016a).” We developed a computer program called, “Konektor”, which automates the generation of 3D printed connections for lightweight structures (Noel 2016b, 2016a, 2017a, 2015). The program takes a surface as input, and generates 3D objects in the computer at the intersections of linear elements based on desired resolution of the structure, location points, length, diameter, and wall thickness of the connection. We used Konektor to increase the scale and complexity of the connections for constructing the architectural form. Fig. 12 shows the labelled 3D printed connections resulting from a Digital Crafting approach to wire-bending using the Konektor software.

![Fig. 12. Labelled 3D printed connections produced from Konektor program and used in the assembly of the lightweight mobile structure.](image)

3 The Konektor software will be reviewed and presented in detail in a later publication by the author.
Crafting Fabrication of the Skin

The structure’s neoprene skin would comprise triangular fabric components, each shape unique to its specific location on the structure. For the full-scale design, however, a Crafting Fabrication approach was taken – “the use of digital and non-digital tools, processes, and technologies [...] in the [...] fabrication of artifacts” (Noel 2016a). Since the behavior of the fiberglass rods and 3D printed connections would not become apparent until their assembly, the textile skin was cut to match the real physical dimensions instead of the digital dimensions. Due to size limitations of the laser-cutter bed, each component was drawn, labelled, and nested onto the 5’-0” wide roll of fabric by hand, then cut with a pair of scissors (Fig. 13).

![Fig. 13. Crafting Fabrication approach to nesting shapes and cutting fabric components for the skin of the lightweight form. Components were drawn onto the fabric and cut with a scissor.](image)

3.2.2  Steps 6: Assembly of the Structure and Skin

Fiber-glass rods were used to construct the form, with rods labelled and cut according to their required length. Since rods were a maximum 6’-0” long, customized 3D printed connections were designed and labelled to join rods together (Fig. 12b). The main rods for the structure were pushed through their specified labelled connector, with connectors placed at their designed locations along the curves. Masking tape secured the rods in the 3D printed connectors, similar to its application in the Bailey-Derek Grammar (Noel 2015). The assembled fiber-glass structure is shown in Fig. 14. Hot glue adhered the double-sided neoprene skin to the fiber-glass structure.
Fig. 14. The assembled lightweight mobile structure constructed from fiber-glass rods, and 3D printed connections.

Figure 15 shows the lightweight mobile structure designed using parameters developed from costuming and dancing sculptures; and fabricated from a novel approach to wire-bending with fiber-glass rods, 3D printed connections, and a textile skin.

Fig. 15. Photograph of final structure with a person for scale

4 Contributions

This work has promising contributions for costuming and dancing sculptures; architecture; computational design; and traditional craft practices. First, for dancing sculptures in the Trinidad Carnival, we offer a new approach to design that builds on the language and movement of existing traditional sculptures such that designs in the cultural practice continue to evolve. We also offer a novel production system for
constructing these artifacts, by building on wire-bending. For architecture, we propose a possible approach to generating architectural form using movement, and spatial elements of the body and dancing sculptures as points of departure. We also suggest the prospect of constructing lightweight architectural form from materials and techniques built on a traditional craft. Like Asokan and Cagan’s embedding of culture in artifacts through their movement grammar, we also embed culture in architecture by creating a shelter derived from the form, movement, and craft in a cultural practice. Third, we offer the beginnings of parametric descriptions of dancing sculptures and their relation to the body. These parameters can be used for analysis and synthesis of dancing sculptures and applied in costuming or architecture. Finally, for traditional craft we offer an example of how a practice might be reconceptualized through computation and digital technology for architectural application. We introduce briefly the development of a novel digital fabrication computer program for rod structures. In addition to the aforementioned, we also redefine what a dancing sculpture is: a large 3D sculpture supported by the body, that communicates human energy, makes us aware of our bodies, its actions, and the surrounding world.

5 Discussion

This project demonstrates a system for designing and fabricating a dancing sculpture, and lightweight architectural structure based on dancing sculptures in the Trinidad Carnival. Design rules developed from analyzing the movement, form, and spatial relations of 14 carnival characters and dancing sculptures were used to design a new dancing sculpture and architectural form. A new digital approach to wire-bending created 3D printed components to construct the architectural structure. Building on the work of Sass and Botha (2006) who developed a production system for small wood framed buildings using a CNC router for wood-framed structures, this work suggests an alternative approach to using digital fabrication in the construction of shelters on-site with a high-precision machine, a 3D printer. Our small shelters could be transported and erected from fiber-glass rods, 3D printed connections, textile, and masking tape, all light and easily transported by an individual. Application of this work allows for the erection of temporary shelters for pavilions and camps. These lightweight architectural structures can be aggregated to create shelters for larger objects and numbers of people. By properly planning its disassembly - removing and stacking the textile skin in order, removing fiber-glass rods from their connections, and safely storing the 3D printed connections - one can easily disassemble the structure, and store its components for repeated use. The Konektor program made construction easier since each component was specific to that location, guiding assembly and error correction in erecting the design. Using the Crafting Fabrication approach to install the skin, resulted in less material waste, and fabrication based on the real dimensions of the erected physical structure rather than the planned dimensions from the digital model.
One limitation of this study was the size of the structure. Although the lightweight mobile structure can currently only fit 1-2 people in a sitting position, it still provides us with the foundation to begin designing and constructing larger shelters and pavilions for greater numbers of people. Since hot glue and masking tape was used to secure the textile skin and the tensile rods respectively, the durability and integrity of the structure is not the best. Future studies will explore ways to better secure textile surfaces and connections. Due to the increased complexity of some 3D connections and the tension in the rods, additional structural elements had to be modelled into the connections to prevent failure and breakage. Future studies will look into addressing this issue. Some future questions to be addressed include: How might we use a modular approach to design to create larger networks of lightweight structures? How might we embed material and structural behavior in design to aid in construction? How might designing for kinetic feedback from dancing sculptures to the body further inform our corporeal experience, and design?

Acknowledgements. This work is dedicated to wire-benders Stephen Derek and Narcenio “Senor” Gomez, and mas’ designer, Peter Minshall. This work was funded in great part by The Government of the Republic of Trinidad and Tobago, and in part by The Stuckeman Center for Design Computing. Grateful acknowledgement is given to Xiao Han, Danielle Oprean, Felecia Davis, Daniel Cardoso Llach, and Benay Gursoy Toykoc for their support. Special thanks to my friends at the Stuckeman Family Building.

References

secure the textile skin and the tensile rods respectively, the durability and integrity of surfaces and connections. Due to the increased complexity of some 3D connections pavilions for greater numbers of people. Since hot glue and masking tape was used to mobile structure can currently only fit 1–2 people in a sitting position, it still provides us with the foundation to begin designing and constructing larger shelters and

Acknowledgements.

This work is dedicated to wire-benders Stephen Derek and

One limitation of this study was the size of the structure. Although the lightweight

Family Building.

Gursoy Toykoc for their support. Special thanks to my friends at the Stuckeman

of 'cultural Languages' to inform our corporeal experience, and design?

6. Jackson, W.: Carnival: Calypso, Steelband and Trinidadians. In L. Lonsdale (Eds.), Dance in


AIGA: The Traditional Masques of Carnival, Caribbean Quarterly 4 (3/4): 194


Minshall, P.: From the Bat to the Dancing Mobile: Technology in Mas (Illustrative Essay) (1990)


27. ———: (Re)conceptualizing Wire-Bending in Design: An Exploration of Craft, Computational Making and Digital Fabrication, poster presented at the SCDC Flash Symposium, Pennsylvania State University, April (2016b)
29. ———: Konektor: A Tool to Design and Fabricate Lightweight Structures from Lines and Rods, in Unpublished Work (2017a)