USING MOBILE DEVICES IN TEXTILE ARCHITECTURE DESIGN (iPad/iPhone)

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Summary. The aim of this article is to explore the use of Mobile devices in the textile architecture field. Some Apps for iPad/iPhone/Android exist that cover general architecture aspects such as design, sketching, drawing, CAD viewers, calculators or project Management. A specific App for textile architecture conceptual design is proposed in this paper.

1 INTRODUCTION

This paper describes the use of mobile devices in different fields and shows how textile architecture can take benefit of it.

1.1 Mobile devices

Last generation of mobile devices, such as iPhone, iPad or Android based devices are changing the way the users interact with data and technology. Mobile devices bring the users a new way to deal with traditional computer tasks: browsing Internet, sending emails, accessing calendar or playing music and video.

Since the launch of the first laptop computers in the 80's, the term mobility has been a key factor in the design of computer devices. Laptop sales increased considerably compared with desktop computers sales in the 2000's.

Mobile devices have become more popular since the launch of the iPhone in 2007. Further devices as the iPad or the Samsung Galaxy Tab offer similar capabilities with a bigger screen (7 to 9.7 inches), using always a touch-based user interface.

The rise of tablets popularity shows that in a short time, they would become an alternative to laptops for a great of number of users, especially those dealing with Internet and multimedia.

Mobile devices are capable of running apps. There are a vast variety of apps, grouped in categories such as music, games, books, education, medicine, entertainment, business or social networking. Figure 1 shows a picture of the iPad apps being created for each category in the iTunes App Store.

Although games and entertainment seem to be the most popular categories, everybody wants to have presence in the mobile app market. Fields such as medicine or architecture have already started to migrate their products to this new platform.

The emergence of this new platform would be compared to the appearance of the Internet in the 90's, where most of the companies adapted their products to fit the new standard and have a dedicated space in the web.

Mobile devices will become the standard in the next few years, so we should be prepared for this change and create new products oriented to the textile architecture field.

Figure 1. Mobile devices. iPad Apps categories

1.2 Mobile Apps and Architecture

Mobile devices offer Apps that make life easier to field engineers and architects. Mobility is a key factor, which allows the users the possibility of working anywhere at any time.

Some of these apps are oriented to design, sketching or DXF viewers. As example of this, Autocad and Rhino [1, 2] have implemented mobile versions for iPhone/iPad in the last quarter of 2010.

Figure 2 shows some screenshots of iRhino 3D. The app allows users to view native 3DM files on the iPad, iPhone or iPod touch.
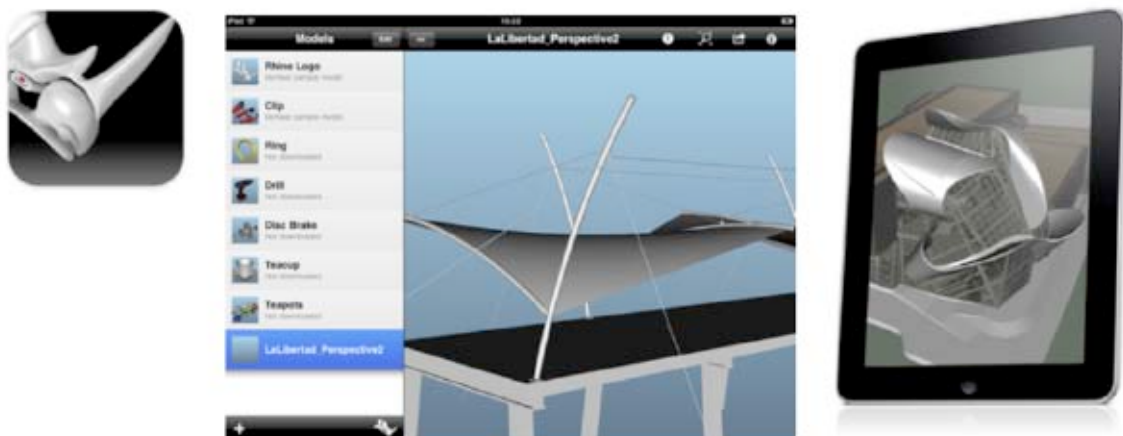

Figure 2. iRhino 3D for iPad/iPhone/iPod touch

It is a great app to show the design and ideas when the user requires mobility. It is just a viewer that allows the user to rotate, zoom or pan the model with a tap or drag of the finger. The user can't edit the models; they are represented as a collection of polygon and meshes. The models can be downloaded from websites, google docs, email attachments or iTunes. Views can be saved as images for markup or emailing.

Autocad has also presence in mobile devices. Figure 3 shows some snapshots of the iPad App, named Autocad WS and launched on Sept 2010. The app is also available for web browsers and allows the user to sync there models online using the file manager. The App includes the traditional drawing tools (line, polyline, circle, rectangle…) and editing tools (mode, scale, rotate, erase, copy…).

Figure 3. Autocad WS for iPad

Other popular apps between architects and engineers are those related to geolocation, unit conversion, measurement, material libraries, or technical calculators between others.

There are also some other specific tasks that would require using a tablet instead of a laptop, especially on field tasks such as surveying.

2   MOBILE APPS IN TEXTILE ARCHITECTURE

This paper introduces an iPad App for textile architecture conceptual design. Figure 4 shows some screenshots of the prototype. The purpose of this app is to create a 3D graphic scenario, in which the user can easily interact with the membrane structure, creating and editing its shape.

Dynamic movement as rotation, translation and zoom are performed by means of pinch or pan gestures, as it will be explained later in this section.

The basic geometric features allow the user the possibility of adding/removing/editing vertex to the model. Physical properties of the network and the boundary cable can be also easily defined.

The main purpose of this App is to sketch different design solutions. The designer uses basic gestures and works in a multi-touch environment. The model would be emailed in a standard neutral format (DXF), so the user can continue working in a desktop/laptop platform to add further details.
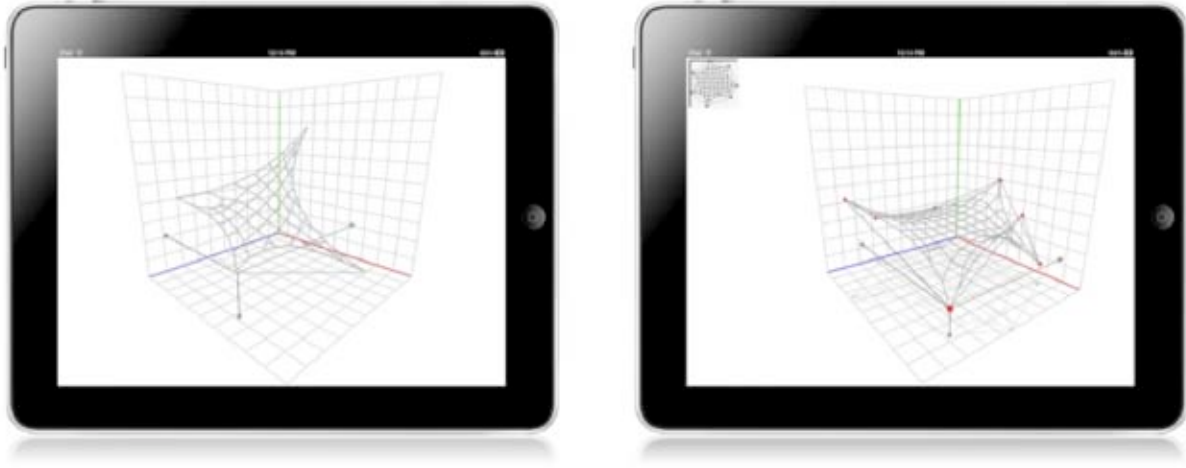
Figure 4. Screenshots of the proposed iPad App for textile architecture design

The app uses the Force Density Method [3,4], which allow obtaining the equilibrium shapes in a really fast, flexible and efficient way. The user can assign different force density values to the boundaries or to the network itself, obtaining new equilibrium shapes easily.

2.1 User interface design

In order to create a useful app, the design should be centered on the user. There are three basic rules that have been followed during the iPad app design, to obtain a good user experience.

- *Simplicity*: there is no need to overwhelm the user with a thousands choices, all at the same level. The iPad is a new platform, so we can't translate the desktop user experience. There is no menu system, no windows system, and no file system. The desktop tasks should be simplified on the iPad platform.
- *Prioritize*: Which features does the app really require? How is the user interacting with them? Which is the frequency of use of these features?.
- *Innovate*: We have created a new way of interacting with a 3D model.

Following these rules it's really easy, really efficient and really satisfying to manipulate the 3D model.

Although the core of creating and manipulating shapes is a structural problem based on the force density method, the success of the App will depend on how good the user interface is designed.

In other words, terms as real time, precision or accuracy are at a secondary level. So, the important point is how the user interacts with the model, which gestures, menu item or buttons are used to facilitate this interaction.

Next sections describe some of the user interface details which have been taken into account during the implementation.

2.2 Interaction with a 3D scenario using 2D gestures

We begin describing the virtual workspace that will be used by the designer while sketching the membrane structure. It is clear that a three-dimensional space will help the designer in the creation of the structure. Figure 5 shows a reference system and a point that represents the position of the user finger. As the user moves the finger, the point moves around the virtual workspace.

But, can you know exactly the location of the point represented on Figure 5a? The answer is no, and it is due to the lack of a reference related to the deep. It means that the same point represented in Figure 5a would have different representation, all of them with the same 2D screen xy location. Figure 5b & Figure 5c show two possible locations of the point given in Figure 5a. The projection of the point onto the three walls facilitates the user to locate the point.
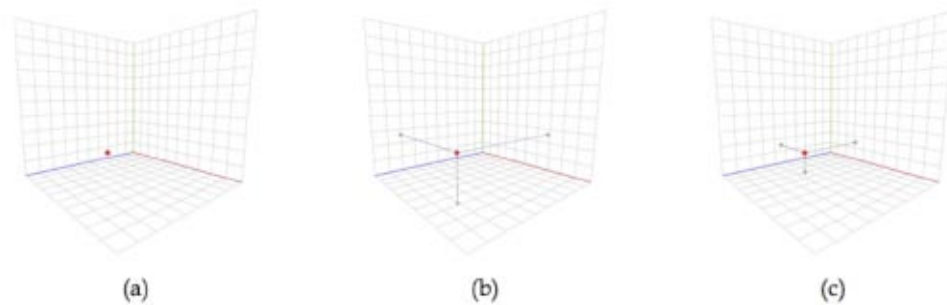
Figure 5. Referencing a point in 3D space using 3 reference planes (a) unreferenced point (b) position A (c) position B

Should we conclude that the three walls and the projections are needed to locate a point in the 3D space? Not necessarily. As you can see in Figure 6b & Figure 6c, the point given in Figure 6a can be located in different ways in the virtual workspace by adding its projection on the horizontal plane.
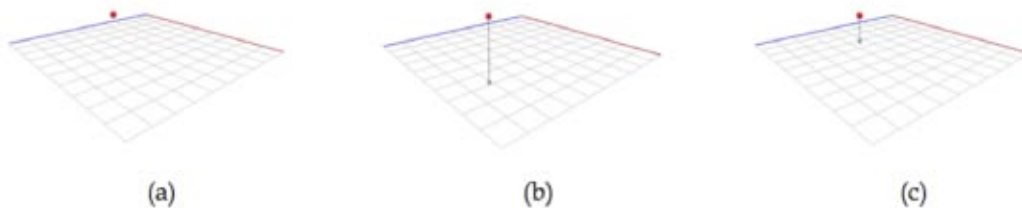
Figure 6. Referencing a point in 3D space using 1 reference plane (a) unreferenced point (b) position A (c) position B

Although this way of representing a point in the 3D space seems to be something very common and trivial, the majority of 3D CAD systems use the traditional mouse as a 2D input device, using different strategies to give the user the feeling of being immersed in a 3D scenario. CAD applications usually combine the movements of the mouse with a keyboard input to restrain the movement of the pointer into a certain plane or in a specific direction.

In our case, we have to combine gesture movements with other controls that restraint the movement to a vertical direction or inside an specific plane.

2.3 Dynamic interaction using 2D gestures

It is important to define how the user interacts with the model in order to apply dynamic movements such as rotation, scale or pan. Figure 7 shows the user getures. Following are defined these actions:

- *Scale*: The iPad user experience associates the pinch gesture with zooming, so we are keeping it for our App. See Figure 7a.
- *Rotation*: a natural gesture to rotate the model is just moving one finger on the screen. The model will rotate around its center of gravity. See Figure 7b.
- *Pan*: Panning is achieved by touching the screen with two fingers and moving around. See Figure 7c.

The user can easily swap between the zoom and the pan action since both gestures use two fingers. Rotation and pan can also be easily combined. As example, if the user is rotating the model moving the finger, he can start panning just adding a second finger to the screen and continuing the gesture.
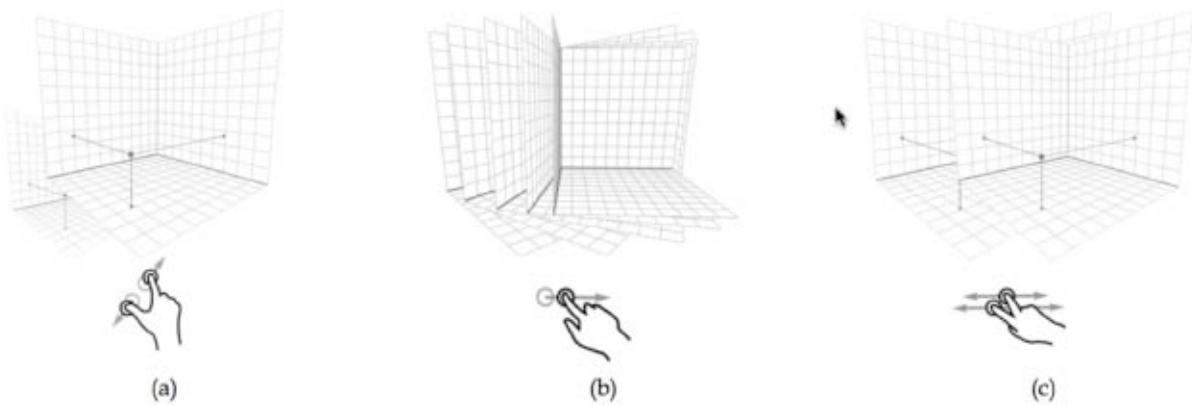

Figure 7. Main gestures. (a) Zoom/scaling (b) rotation (c) panning

2.4 Mesh control

Once the main scenario features have been described, it is time to talk about the representation of the equilibrium shape of the membrane structure. As stated previously, the formfinding method used for obtaining the equilibrium shape of the structure is the force-density method.

The model needs to be discretized in nodes and elements to calculate the equilibrium shape. This mesh is based on a control polygon, which contains the fixed vertices of the membrane. The example shown in Figure 8a shows the location of the seven fixed vertices of the membrane, which are joined to create a closed polygon.

The projection of this polygon on the bottom surface defines the boundaries of the mesh. This mesh consists of quadrangular elements as shown in Figure 8b. Figure 8c shows the final equilibrium shape.
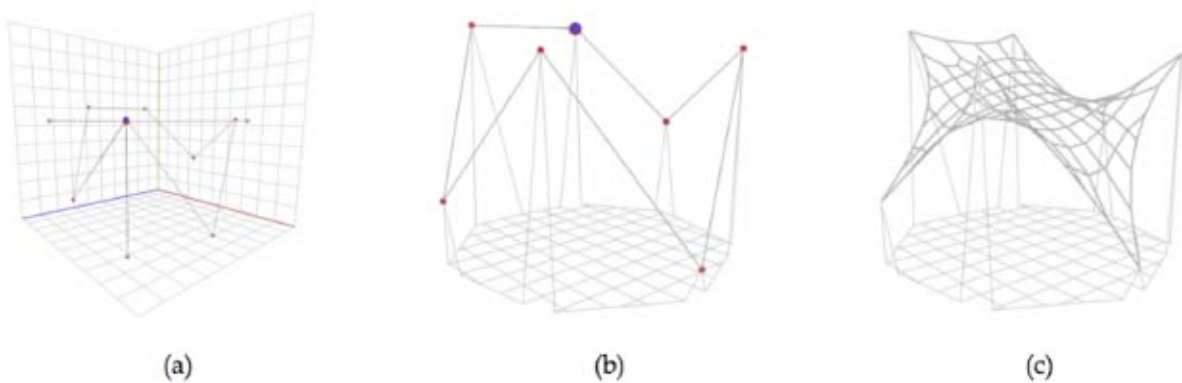
Figure 8. Equilibrium shape (a) control polygon (b) mesh before equilibrium (c) equilibrium shape using formfinding

2.5 Restraining gesture movements

In order to facilitate the user interaction with the membrane vertices, it is possible to restraint the user gestures into a specific direction.

Figure 9a shows how the finger gets to the vertex and a control polygon appears in the scene. A button is added in the toolbar to allow the user to move the vertex only in the vertical direction. A vertical line is shown to tell the user visually that the vertical movement is allowed (see Figure 9b). While dragging the vertex vertically, the polygon control is updated according to the new vertex location. Once the desired position has been reached, the new equilibrium shape of the membrane is represented and the control polygon disappears of the scene. Figure 9c shows the new equilibrium position.
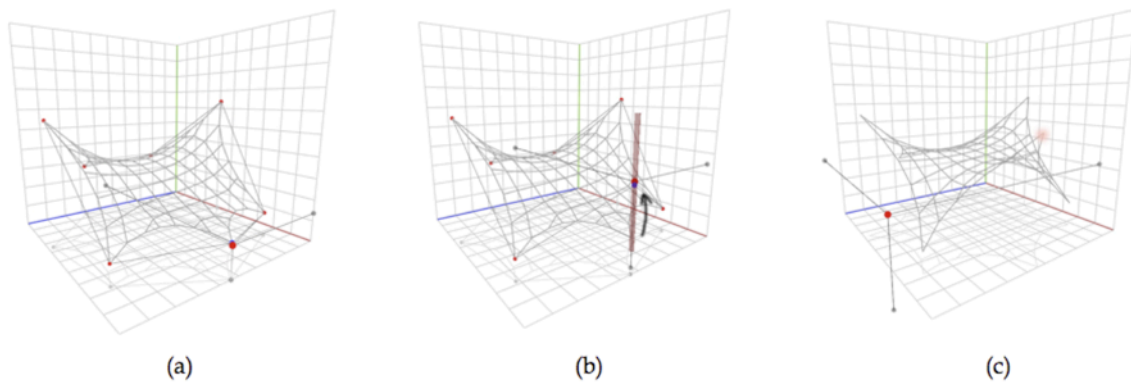

Figure 9. Moving a vertex vertically.

It is important to emphasize the importance of the shades projected on the three main planes. They can be used as reference while modifying the position of a vertex or when new geometry is added to the scene.

In some occasions, it can be interesting to have the possibility of moving a vertex inside the XY plane. The procedure is similar to the movement in the vertical direction. Again, the user should approach the finger to the location of the desired vertex (see Figure 10a). The

control polygon appears again and the movement of the pointer is restrained to the horizontal plane.

A small 2D top view of the membrane structure is located on the top-left side of the main scene (see Figure 4). This is a very helpful view for the designer to see the appearance of the membrane while dragging the vertex horizontally.
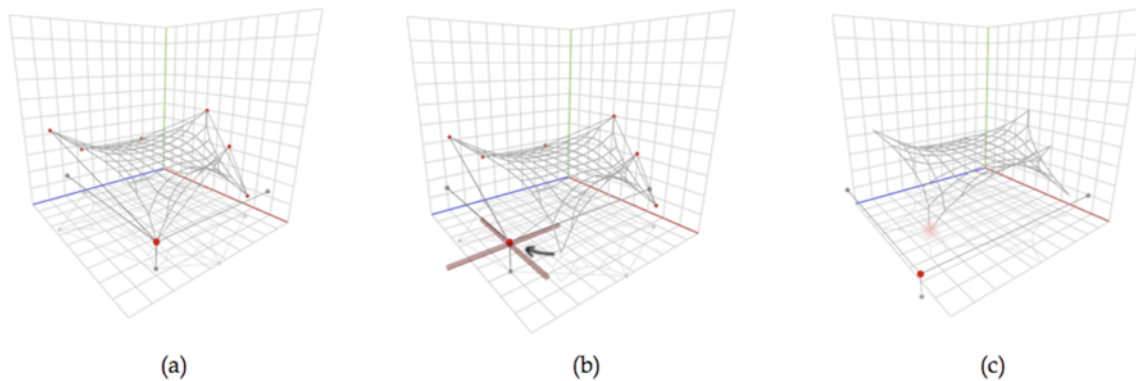

Figure 10. Moving a vertex inside the XY plane.

2.6 Physical properties

As it was stated before, the force-density method has been used as formfinding method for the calculation of the equilibrium shape of the membrane. This method requires the introduction of the force-density values. Since the application is being use by designers at the conceptual stage of the design process, it is preferred to avoid the introduction of numerical values by the user. So, how can the user change the force-density values without introducing the numerical values?

Let's think about the meaning of the force-density value. This value is the ratio between the internal force and the length at each bar of the structure at the equilibrium shape. Although each bar of the mesh could have a different force value, it is not usually an efficient practice. The most common practice consists on assigning two force-density values to the internal mesh bars, and one force-density value to the bars of each edge of the membrane structure. The two internal force-density values are associated with the two main directions of the membrane and they use to have the same value, since the membrane material is isotropic.

As the force-density value just relates the relation between the internal bar force and its length, we can have the same equilibrium shape if all the force density values of the membrane are scaled.

So, to make easier the conceptual design process, the user will increase and decrease the value of the force density values by means of sliders. The force density value would be the same for all the edges, or have a different value for each edge of the membrane.

Figure 11 shows different equilibrium shapes of a membrane with different force density values at one of the edges. It can be seen the difference between Figure 11a with a 1:2 ratio and Figure 11c with a ratio of 1:50
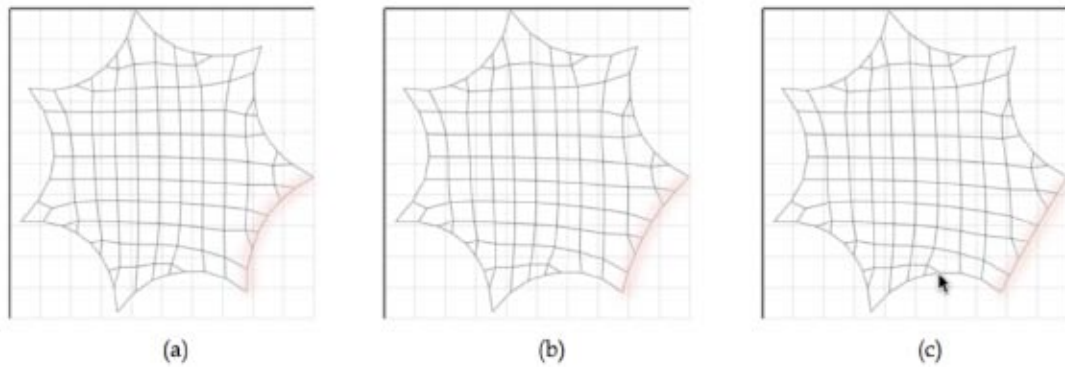
Figure 11. Edge force-density ratio. (a)1:2 (b) 1:5 (c) 1:20 (d) 1:50

3   CONCLUSIONS

Mobile devices are changing the way the users interact with traditional computer tasks: browsing Internet, sending emails, accessing calendar or playing music and video. It seems that the future of technology tends to be the use of mobile devices. It is a great challenge to convert traditional desktop/laptop tools, using new multi-touch devices to make life easier to field engineers and architects.

Some CAD manufacturers as Autocad and Rhino have already point in this direction and have a specific product for this platform.

In this paper, we have explored the possibilities of using the iPad for textile architecture design purposes. Simplicity, prioritization and innovation are the key factors to the success of the app.

The app uses the force density method to calculate the equilibrium shapes. The main features of the app include the dynamic control of the 3D model, creation and edition of vertex and modification of physical properties of the membrane.

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