Integrated Adaptive and Tangible Architecture Design Tool

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In this paper, we identified two majority issues of current CAAD development situating from the standpoint of CAAD history and the nature of design. On one hand, current CAAD tools are not adaptive enough for early design stage, since most of CAAD tools are designed to be mathematical correct. As we conducted a detailed survey of CAAD development history, we find out that most of the techniques of Computer-Aided Design applied into architecture are always adopted from engineering track. On other hand, the interaction between Architects/Designer and CAAD tools needs to be enhanced. Design objects are operated by 2d based tools such as keyboard, mouse as well as monitors which are less capable of comprehensively representing physical 3D building objects. In addition, we proposed a working in progress potential solution with HCI approaches to fix these issues. We summarize that, the prototype proved that architects and designers could benefit from utilizing adaptive and tangible design tools, especially during massing studies in the early phases of architectural design.

Keywords: CAAD development, Human Computer Interaction, Tangible User Interfaces, Design Tool development, Design Process

INTRODUCTION

As an ever evolving discipline, during the past few decades, the WIMP based CAAD tools have been redefining the foundation of architectural design and made extraordinary contribution to architectural practice. Meanwhile, it is also reshaping the typical workflow of architects and designers. Nowadays, with the further development of computer system and CAAD techniques, the expansion of building scale, the increasing complexity of architectural practice and collaboration, the existing CAAD exhibits a series of drawbacks while the new emerging technologies are changing the people’s cognition of design activity. In this paper, we identified two majority issues of current CAAD development situating from the standpoint of CAAD history and the nature of design.

According to the recent cognitive neuroscience study, there are likely two ways that design idea usually occurs, one view is the instant inspiration like a lightning strikes, and another view is that the design idea is generated through continuing firmly attempts. It seems to be two opposite ways but both these two views are describing the same aspect of
one process but on different levels. If considering design as an instant inspiration, it is actually the culmination of a series of intelligent process. As Pablo Picasso’s quote “Inspiration exists, but it has to find you working” indicated that great ideas and eureka moments arise from everyday work. A designer have to at least be thinking about a topic or problem before he or she can find a creative solution. In addition, the goal of continuing attempts is for getting the best ideas which come out of the procedure itself. Design, as a continuous creative process, one of its main task is to capture and organize these insights and inspirations which accumulated through continuing attempts then expand the design idea to a larger scale and more practical level.

One challenge for architects and designers is that, architecture as the final result of design process is a complex and systematic product, and it requires long-term memory and significant information input. But human are more suited to short-term memory work and relatively less information input. Long-term memory work is not easy to carry out for human and it is not capable of being used for a dynamic process such as design. This is why nowadays architectural design process has always been break down into multiple steps such as concept design, schematic design, etc. In addition to the workload subdivision, people started using different kinds of external representation to divide problems into smaller conceptual element and different aspect of design, such as different levels of 2d drawings and 3d models which can be easily manipulated within the limits of short-term memory. At early design stage such as concept design, designer needs to offer an initial design concept to address the design problem. The concept is usually formed by establishing relationship between certain numbers of design elements. That requires that, while helping to record and organize designers’ inspirations, the design tools to be used in the early design stage need to assist locating design elements and establishing relationship between these elements.

The emergence of computer and computer graphic system laid the foundation of computer-aided architecture design which has become the new tool and took over the dominant role in the architectural industry. Since the 1960s the first CAAD program which was liberated architects from blueprints by hand, architects have been employing the power of computer, more specifically, architecture-specific software into architectural design and practice. However, many of this software root in other industries, for example, Maya and 3Studio Max for computer animation industry and CATIA for aircraft manufacturing; while some are developed for the use across a wide range of industries, such as AutoCAD for mechanical engineering and architecture. In the following decades, CAAD has greatly changed the workflow in architectural industry and architects are benefited with higher drafting efficiency.

**Problem A.** Through the investigation of current CAAD tools we conducted, we found most of the CAAD tools are designed to be numerical driven and mathematical correct. It is not flexible enough for early design stage. The learning and memory costs, non-intuitive input method and unfriendly interface, all of them are responsible for architect’s heavy workload and unnecessary repetitive work. They seem inevitable because of their industrial root. No existing approach can penetrate the core of designing, which is how designers work through creative processes to generate design solutions. It is awkward that almost all popular concepts about design tools have been established by people who do not personally design architecture but by software engineers.

The concept of CAD appeared the 1960s, but the definition of CAD keeps changing. During the earlier phase of CAD development, when Ivan Sutherland invented his Sketchpad at 1963 which integrated evolving design and analysis programs, CAD stood for Computer-aided Drawing (Drafting) instead of Computer-aided Design which were usually known by us. At that time the goal of CAD is drawing 2D...
document which continued until 1970s. Aleksander (1999) and Kalay (2004) illustrated that three generations of CAD tools have been invented in the history. The first generation CAD systems were designed to be intuitive and architectural. But the shortcoming of 1st generation CAD is that the system contains excess elements of architectural design procedural and lack of graphic interface, so that the solution is quite hard to popularize. It is worth mentioning that the geometric modeling route CAD system which was another first generation CAD route based on 2D wire frame model led by an industry giant had already been applied in engineering practicing while the architectural specific route CAD was still in pilot phase. With the growing demand of automotive and aerospace industry in 1970s, engineers desired to find new solution for defining complex geometry. The earlier CAD approach of geometric modeling system was a quite simple wire-frame system. It can only present basic geometry information, yet cannot effectively represent the topological relationships between geometric data. In 1962, a French engineer Pierre Bezier formed new surface and curve designing method, which let the problem of computer drawing curve became operable. Meanwhile, French aircraft manufacturer found a way to build free form surface in computer based on CADAM system. It is first time to completely describe the main information of 3D product’s element. Thus, CAD technology has been broken through from 2D wire-frame modeling to surface 3D modeling expression.

In 1980s, the demand of architectural company had changed. Not only drafting, architects started to use computer communicate with different project participants. The second generation of Architectural CAD system focused on drafting and modeling, rather than the first generation system which more focused on building design procedural. It was also defining different types of geometries rather than defining the building element properties. But comparing with previous context, we can summary that the second generation CAD of architectural design such as AutoCAD is quite similar with the CAD technology used in engineering industry in early 1970s. They all focused on 2D and 3D geometry such as line, polyline, surface and simple geometric relationships. Even though some companies started to develop rendering and modeling software for architects, it still just followed the action engineering industry. At the same time, engineering industry had already start their new experiment. Although the previous CAD technology of engineering has had the description for 2D and 3D geometry, but still hadn’t find a way to present geometry’s physical properties such as quality, the center of gravity, moment of inertia. Engineering researchers successfully achieved the solid modeling technology which can illustrate the topological relationships as well as the geometric properties. The first commercial solid modeling application was released at 1979, which was called I-DEAS. The solid modeling technology was based on unconstrained free-form model, users can directly modify geometry model, but the disadvantage is that cannot provide non-geometric information such as material, processing, etc.

But architectural design is a complex activity. The third generation of CAD system had become far more complex than the previous generations, architectural elements are interdependent, and the number of these elements is uncountable, if any of the data in the system goes wrong, it will have serious negative impact on entire project. Then, how should architects deal with the situation which has large number of associated data. Just like we’ve mentioned previously, engineering design tools are always adopted by architectural industry. In the current engineering industry, they’ve applied parametric and variable modeling techniques to solve these problems. Parametric technology is feature-based, full-size constraints; all data correlated each other, dimension-driven design, completely overcome modeling free form unconstrained state. Beyond the completing logical structure, parameters can be modified at all times. Variable modeling technique is developed based on parametric technique. Such as Grasshopper, Generative Component, Digital
Project are the best examples to illustrate how architectural professionals apply the engineering technology into architectural industry.

Because of the practicality, reliability of architecture are emphasized, it is almost impossible for any form of experimental reforms to firstly happen in architectural industry. Just like the invention of the elevator led to the rise of high-rise buildings, the practical needs of architectural technology will not exceed the needs of social productive forces. Hence, adopting technology from other areas is understandable. But the learning process that current CAAD tools required, dis-intuitive input and unfriendly interface, is leading to architect’s heavy workload and unnecessary repetitive work.

The nature of architectural design is a materialization process reflecting the designer’s creative thinking. The design process is imagination interacting with the assistance of all kinds of tool. The think pattern behind this process is from abstract transiting to concrete, from flexible to accurate. But the current CAAD tools which adopted from engineering track or developed by engineers are mostly numerical driven asking for an accurate numbers to be employed even the design is still situated in the early stage. But the mathematical approaches for design decision-making are not capable of handling uncertainty, multidimensional complexity, and flexible compromises. In addition, according to Simon’s book: The Sciences of the Artificial, design as an iteration process, repetitive work is unavoidable. The optimized CAAD tools should provide sufficient adjustable space allowing designers to make changes to reduce the repetitive process. Designers and Architects are expecting to be provided with assistance of establishing relationship with flexibility from CAAD tools instead of emphasizing accuracy. (see Figure 1)

**Problem B.** On other hand, the interaction between Architects/Designer and CAAD tools needs to be enhanced. The currently CAAD tools are fundamentally limited within WIMP interface, which employ 2d based input manipulation and 2d based output display. Design objects are operated by 2d based tools such as keyboard, mouse as well as monitors which are less capable of comprehensively representing physical 3D building objects. Design is an act of seeing, thinking, and making. Which involving eyes, brain and hands. Architectural designers are responsible for designing the aesthetics and spatial details of a building - the building's size, shape, space utilization, and site requirements.

That requires that no matter which tool designer selected, pencil, mouse or something else, design aids should assistant the coordination of interacting among eyes, brain and hands. Through the association of brain, hands and eyes, architectural designers are aware of information; through the repetitive creation, architectural designers would have chance to re-define information and get feedback so that they can make the right decisions.

To any architect, the interaction process with computer for their work is not only using tools. It terms of a type of progressive skill-building, different way to interact with tool which engages different body parts, definitely has a great impact on the work efficiency And human cognition. To some extents, computer games have one thing in common with the work flow of contemporary architects- progressive skill-building. The biggest computer game on the world, Wii and Sony have bring various remote controllers to free players from limited There will never be a certain answer on which is the best to engage human brains to improve skills and make progress on the path to mastery. But obviously, it’s wise to limit it on keyboard and mouse exclusive while any other industries are Seeking for wide variety of alternative and trying to keep their occupation engaged with work by innovative experience.

The CAAD tools provides architects/Designers a new way and means to explore the new idea, and introduces designer a new metaphor to see, to think and to make. But, if architectural designers didn’t actively and critically consider that the changing of technology would impact on our ability to communicate and think, the CAAD technology will be crippling. A brand new CAAD tool needs to be cre-
ated which will further inspire designers by weakening operation and providing more flexibility at early stage. In this paper, situating from the standpoint of new emerging techniques, we provided a survey of tangible and adaptive design tool and their potential of being applied in design space. In the past two decades, as computer science and human-computer interaction have risen to a popular topic over the world, traditional architectural digital tools have been reviewed from an interdisciplinary perspective. The efficiency of perception is associated with the interaction methods so as the influence of these tools’ interface in architecture industry has been enlarged. Tools with tangible user interface is one of the good examples among the innovations of tools to help the translation between physical world and digital world and provides an open mind on architect-friendly and intuitive input and display methods.

BACKGROUND AND RELATED WORK

We evaluated few innovative digital technologies such as Tangible User Interface and The shape-changing technology which can be potentially adopted into design space and help to optimized design tools.

A tangible user interface is one in which the user interacts with a digital system through the manipulation of physical objects linked to and directly representing a quality of said system. In 1997, MIT media lab presented a new vision of “Tangible Bits” at the CHI ’97 conference. The concept of Tangible User Interface (TUI) that is based on physical embodiment of digital information & computation, in order to go beyond the current dominant paradigm of “Painted Bits” or Graphical User Interface (GUI). Humans have evolved a heightened ability to sense and manipulate the physical world, yet the GUI based on intangible pixels takes little advantage of this capacity. The TUI builds upon our dexterity by embodying digital information in physical space. TUIs expand the affordances of physical objects, surfaces, and spaces so they can support direct engagement with the digital world. The idea with Tangible User Interface is to have a direct link between the system and the way you control it through physical manipulations having an underlying meaning or direct relationship which connects the physical manipulations to the behaviors which they trigger on the system. This last statement is where the secret lies. It’s not just a question of having a physical controller for your digital system for the sake of having one, but
making sure that by implementing one, it’s use makes sense to the user and has added value for a more natural and intuitive control of your design. In a sense, the interface becomes virtually invisible, as the user has an inherent knowledge of manipulations such as grasping and moving objects (after all, we’ve been practicing since we were toddlers) so user is able to concentrate more on the system and the triggered behaviors than on how to trigger them.

Coelho and Jamie (2007) provide a holistic approach about how to design a shape changeable human computer interface. One of the main ideas is finding the suitable material for building a shape changing interface. Since there are already several types of material are changeable, the authors explore the properties and limitation of the available materials. One of the main challenges of shape changing was its mechanical properties. But currently, the material can respond with a more adequate behavior to its changing environment. The authors point out that some alloy or dielectric will become dynamic under the influence of direct or indirect electrical stimuli. They provided several currently available materials which can change shape. Most of them are alloy and dielectric. The properties of these materials are different than regular material, such as deformation strength or power requirement. The authors cite shape memory alloys as a main material to descrit in the paper. Once heated, shape memory alloys will form a specific shape and it will be able to indefinitely recover from large strains. After the temperature changing, the shape will return to the original form. But shape memory alloys is not suitable for all the applications, it needs to consider forces, displacements, and temperature.

Majken,etc.(2012) defined the endpoint of shape changing, and the mid-point which is called transformation. Transformation is defined into several aspects, such as Kinetic Parameters and Expressive Parameters. Kinetic parameters contain the some physical value like speed, frequency and description of spatially and geometrically values. Another key context in the paper is talking about the interaction, the authors found that in the aspect of shape changing area, there are three kinds of interaction, which is No interaction, indirect interaction, and direct interaction. Direct interaction takes advantage of this bi-directional relationship, and in some cases indirect interaction also uses digital input to change the physical form.

PneUI is novel project developed by MIT Tangible Media Group. The project provides me a brand new cognition of human-material interaction. In the aspect of architecture, we found that people will always pay attention on the objects which could enhance humans some of the sense, but architecture is lacking of ability in this aspect. if the research purpose is combining traditional architecture and human’s daily object to fully interact with users, the Soft Composite Materials could be a great solution. Like it mentioned in the paper: “Hard bodies with construction of rigid structural and electronic elements have limited the form, function and interaction of shape changing interfaces in HCl.” (Vertegaal,2008) Soft bodies could change its shape in terms of users need. PneUI is an enabling technology to build shape-changing interfaces through pneumatically-actuated soft composite materials. The composite materials integrate the capabilities of both input sensing and active shape output. This is enabled by the composites’ multi-layer structures with different mechanical or electrical properties. The shape changing states are computationally controllable through pneumatic and predefined structure. PneUI is consist of multiple layers composite material including liquid, silicon electronics, air passage and an origami structure similar to graphite composites. The combination of these composite materials leads the device be extreme soft and flexible. While this advanced technology is still stay in lab, but it gives us a great vision in the future. Soft objects can be used in the aspect of architecture design process to provide designers some of flexibility bringing more possibilities.

Leithinger and Follmer(2014) introduced an eye-catching project from the MIT Media Lab: A table built with motors, linkages and pins, that can render
a person physically in real time via a digital source. Some articles hailed the technology with potential to change the world and others were captivated by its strange, almost science fiction-type quality. The consensus was that this thing was really, really cool. But for a concept so complex, the initial idea came from a simple beginning. The idea is inspired by those pinscreen toys where you press your hand on one end, and it shows on the other side. However, the 15-by-15-inch table, known as inFORM, is much more complicated than a toy. The choice for the motors came down to function and how Leithinger and Follmer wanted the table to work. They knew they wanted inFORM to be an interactive and perceptive process, meaning they wanted users to physically shape the table as well. The duo decided on the kind of motors that power faders, which are commonly used on audio mixing boards and cost $20 to $30 each. These motors are pretty weak, though, so Leithinger and Follmer used linkages-long cables that reduce friction. Each motor is then controlled by a custom circuit board with a microcontroller, which is then connected to a computer. By moving these pins up and down with computer control, user can form a shape, the shape can be a three-dimensional model you load from a computer, it can be a user interface, or it can be a shape of a remote person. The most complex feat the inFORM can accomplish is the last one-rendering a person or object remotely. For this, the tangible media team decided to use a standard Xbox Kinect, a sensor typically used for motion-intensive gaming, to capture a person’s movement. A mounted projector also displays color. When setting out to create the inFORM display, Leithinger and Follmer-along with Hiroshi Ishii, professor and associate director of the MIT Media Laboratory-had a clear goal. “We really see this as a research platform where we can just quickly prototype things,” Instead of waiting a few minutes or hours for a 3D printer to create a design or using even slower traditional methods of prototyping, testing out different scenarios can happen instantaneously. They also envisioned practical application in urban planning and CAD modeling, though currently in a lower resolution, where designers could physically manipulate their creations and changes would be reflected on their digital compositions. But the prototype device could also be a boon for other industries and areas that the creators never intended.

The limitation of 2.5 D shape display is the geometry cannot be overhang, but another group of researchers at MIT have developed a prototype environment, named ZeroN, which can suspend an object in mid-air and use it to navigate both a virtual and physical environment in a three-dimensional space. Using active electromagnets, the environment can be programmed to manipulate the path of the ball or allow it to be guided by hand. An intriguing feature is that ZeroN can “remember” and play back the movement of the ball, whether programmed or hand-guided, within the three-dimensional space. 

models of “planets” within the environment with programmed orbital rings, guide the ball as it revolves around the model. Adding a second model immediately changes the orbit of the ball, as it begins to revolve around two “planets.” The simulator uses infrared stereo cameras, taken from conventional webcams. The cameras sense the position of the ball and objects within the three dimensional space and plots three dimensional models of the newly introduced objects in the environment. A second instrument for measurement called the Hall Effect Sensor. The cameras can build a virtual model of physical objects position in the ZeroN, which can then allow users to navigate the virtual environment with respect to the ball. The ZeroN’s applicability can range from architectural, gaming or even medical purposes, like virtually navigating the chest cavity of a patient. ZeroN however was built with the purpose of redefining what it means to interact with physical objects. “Our body and minds have developed great capacities for understand and manipulating physical environments. The long-term vision is to embed computation and physical materials that can directly interact with us. In this way, we seek to redefine the relationships humans have with materials, space and
digital information,” Lee said. The prototype is still a proof of concept and has its minor kinks to work out. Audience may notice that the ball’s movement is undoubtedly unstable. The electromagnet, in conjunction with the Hall sensor, which constantly calculates how much repulsion or attraction is necessary to maintain the ball’s approximate position in the three dimensional space, may need to be programmed for a gentler touch. But the video is evidence enough that Lee’s concept works. In fact Lee has begun to build the ZeroN’s second iteration. According to Fast Company, Lee is scaling the prototype to be capable of manipulating multiple objects within the ZeroN environment.

**Methodology**

The concept of direct manipulations to indirect is like driving a car by manipulating the steering wheel and pedals to giving a driver instructions. In the latter case, you don’t necessarily feel the motion of the vehicle.

The same situation has been happening with designers for decades. People are always using the indirect manipulation input to approach the design intent. The limitation is from both hardware and software. For hardware side, the keyboard is utilizing typing to input command, but what’s an architectural designer doing is communicating with object to develop the design idea but not giving command to control the object. What’s designer need is a spatial platform to operate object wherein designers could have a multiple dimension reference. The mouse is seems to be a spatial platform due to its x and y operating space, but it just have two dimension. Using two dimension manipulations to operating 3d space is still missing the depth. For the software side, the WIMP interface is a combination of windows, icon, menus, and pointing. Each of these items is representing a command or a purpose. Sometimes calling one of the icons user will have to find another one. To use the WIMP interface, designers have to pay extra attention on software learning. Especially, some of the interface is not friendly enough for designer to learn and use.

We need to find better methods for designers to interact with their design, not only through mouse and monitor, but also through more intuitive and natural ways to sense and manipulate the project. The most intuitive tool should incorporate input manipulation through a natural language. Natural language in this context refers not only to a language like English, but also to human behaviors such as hand gestures. If the manipulation setting can be based on natural behaviors, it will be easy enough to be learned. The circular flow of information among thinking, observing, and making gives designers the opportunity to dynamically re-define the objects they sense. Body manipulation motivates designers evaluating object from multiple aspects so that inspire appropriate design intent. Grandhi (2011) explored people’s natural gestures using “before” and “after” pictures and instructing participants to perform the gesture needed to get from before to after. The experiment suggested that user experience could be enhanced by developing the gesture vocabulary based on understanding that the actions are embodied.

Given the importance of visual feedback to designers, visual immersion incorporating both geometric and non-geometric feedback, is desirable but current hardware often interferes with UI interaction or communication. An augmented representation as output display has several approaches to enhance the experience of designers and achieve the desired results. We report here on one project that incorporate input using hand gestures and augmented output along with haptic interaction and visual abstraction.

In the physical world when people are manipulating a physical geometry, nobody will think about which gesture I should use to interact with the television. All the gesture come out spontaneously based on current condition. In the physical world, a physical object will provide people haptic reference but not only visual experience. For instance, when you need to open a bottle of wine, observing is obviously not a wise choice to do so, but you will have to touch the cork and hold to pull it up. Haptic feedback can allow
As we discussed in the previous content, tangible user interface could be a possibility. Designers could directly work on a physical object to improve their design with more direct and intuitive interaction. Using a physical object to represent building geometry let designers better experience their design object and feel the proportion of the building shapes. For achieving the concept, we developed HYPERCUBE, which is tangible objects based massing study tool kits.

The general environment of HYPER CUBE contains a projector, an interactive desktop, and several sets of tangible objects based massing study tool kits. The interactive desktop is an ordinary desk covered by rare projection film. It needs to be associated with the projector on the top, and a regular web-cam from button. For the software, it mainly dependents on Processing UDP, reacTIVision and grasshopper. ReacTIVision senses the QR marker and transfer to processing then send the data though UDP to grasshopper.

Currently, we’ve developed three sets of tangible objects based massing study tool kits. The first set is static geometry containing a cube, a keystone, and a tapered. Each of the geometry represent a single building object. At the button of each geometry has a QR marker which can be captured by regular webcam, system also tracks the location and orientation. I did several experiments and found that the regular lighting condition is not suite for the webcam to capture the QR marker. So we insert a 4 RGB LEDs at four corners behind the marker, when the 4 RGB LEDs are activated, webcam will clearly capture the QR marker. For the cube, keystone, and, tapered, each of these geometry has a specific QR marker matching with. When user places any of these geometry above the desktop, the system will be activated. User could move or rotate the static geometries to do the massing study and evaluate what would be the best location and orientation of building. Using static geometry representing building geometry might be sufficient for simply changing the location and orientation. But when massing study start getting involved form finding, the static geometry is not a satisfied option. Beyond the static geometry, I develop the second set which is the transformable twisting block. For each transformable twisting block there is one potentiometer and one slide potentiometer inside the object. The regular potentiometer is mainly recording the rotating angle and the slide potentiometer is mainly recording the vertical height changing. Both of these potentiometer send real-time data into computer, thus the system could apply the data to generate a matched digital model automatically. The button of transformable twisting block is also covered by the QR marker, so the location and orientation information is also trackable.

The transformable twisting block is capable of affording more design tasks, such as evaluating the high raise building shadow situation or curtain wall reflection simulation. But the twisting block just have two dimension to be transformed, the rotating angle and the height. What designers need is more flexibility and less limitation. and all these transformation data need to be send to computer and generate the matched digital model. Based on our vision, we developed the third version of the tangible objects based massing study tool kits.

The third version of HYPERCUBE is made up of 10 transformable edges (two of them is diagonal) and 4 fixed edges. Each of the transformable edge is installed a slide potentiometer which connect to a central micro controller. A QR marker is also necessary for the tracking the location and orientation. Designer consider the CUBE as representation of a single room or a building geometry. He or she will just need to lengthen or shorten the transformable edges to change the shape, proportion, and scale of the cube. Once the central micro controller receive these resistance data, computer will convert them into length, and utilizing trigonometric function to reconstruct the shape of CUBE, all these transformation are remapping into a matched digital model with...
same geometric properties. The 3-dimensional physical CUBE provide direct manipulation and tangible representation of architecture geometry.

**SUMMARY AND FUTURE WORK**

In our paper, we have introduced interactive 3D architectural design tool prototypes called Hyper Cube. The prototypes allow users to directly interact with physical 3D objects using nature or pre-set hands gestures. I described the system implementations, focusing on the workflow for developing gesture interactions (visualization and gesture recognition). We illustrated several interactions that the prototype support, and described application scenarios and possibility.

We summarize our contribution as follows: Developing several system allowing for 3D geometry being created and manipulated through interactions based on user gestures, while leveraging the affordances of enhancing the visual experience or providing haptic reference and good hand gesture to approach appropriate fully 3d working environment. This research highlights that it is possible and helpful for designers working in a total 3d environment.

The study space of designer oriented physical design tool remains partially unexplored. Our research is attempting to establish an understanding of the space as well as develop several system prototypes which could embody the vision we seek to explore. The invention of Integrated Adaptive and Tangible Architecture Design Tool will potentially completely change the traditional workflow of designers and bring them brand new working experience.

The research we've conducted thus far makes me realize that the study of adaptive and tangible architecture design tool will not be wholly accomplished, understood, and delivered within the domain of design study, or the domain of Human-Computer interaction research. Instead, the work I propose resides in the connection between multiple areas - an interdisciplinary environment which is necessary condition to support.

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