WEATHER REPORT:
STRUCTURING DATA EXPERIENCE IN THE BUILT ENVIRONMENT

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ABSTRACT: With the influx of data into the everyday, users demand an interactivity that is localized and immediate, connected to and informed by exhaustive information across space, time, and discipline. As the data cloud burgeons through a plethora of types of inputs, designers grapple with frameworks for analysis and visualization, and the experience of interacting with information remains visually strapped to surfaces of digital display or pre-set as largely static objects. As the Internet of Things develops and the built environment becomes sensing and automated, the ability for all people to engage with, understand, and have a role in the complexity of data input and output requires a new paradigm for building, one in which data is an intelligible component of an environment that is continual, receptive, and communicative. This paper analyzes Weather Report, a constructed environment driven by user-informed data collaboratively designed by an interdisciplinary group of architects, landscape architects, and computer scientists. The aim of this paper is to discuss the assets and liabilities of a spatial data experience posed by the project, framed through questions of design agency related to data input, user interaction, and a plurality of design voices, and the implications of this innovative approach on broader practices. It suggests that a field we term “spatio-data design” might be an emergent area of study, where the built environment is as informed by the management and choreography of data as it is by the traditional assembly of physical materials and components.

KEYWORDS: data visualization, mixed computer and human data, spatio-data design, interdisciplinary design collaboration, design agency

INTRODUCTION

The availability of large amounts of data with the rise of computing has led data visualization today to be predominantly digital, using high-definition displays to organize pixels. Yet with expanding technological possibilities, data that is managed digitally need not only be represented digitally. As physical controls and displays emerge within the field of information visualization (Jansen, 2014), researchers in the arts and design are exploring links between the digital with the physical. Some recent examples of physical data visualization range from static displays, such as Centennial Chromagraph (Marcus, 2014), to dynamic displays, such as Daniel Rozin’s 1999 Wooden Mirror. Though a majority of physical visualizations are object-scaled, some are building-scaled, such as the full-façade Greenpix media wall by Simone Giostra & Partners (Etherington, 2008). Most architectural media walls, however, are still limited to surface, and arguably glorified digital displays. By working at the intersection of architecture and computer science, we challenge approaches that merely represent data on a two-dimensional surface, offering instead data that is experienced as a thickened space. In a world moving towards virtual reality for its capacity to convey data spatially, this project offers another approach to immersive data visualization.

Bernard Tschumi said “architecture is about designing conditions, rather than conditioning designs,” and that it is about “identifying, and ultimately, releasing potentialities hidden in the site.” Through Weather Report, an interdisciplinary project constructed for the 2016 Northern Spark Art Festival in Minneapolis, we aimed to design a condition driven by data, memories, and exchange. The project is an environment under continuous change; a light-filled, spatial experience in which architectural character is determined as much by those who experience the space and by streaming data feeds, as it is by the hands of the designers. Challenging the idea that designers must remain in constant control of their work, Weather Report represents a strategic and choreographed approach to design authorship. As its designers, a group of architects, landscape architects, and computer scientists, we developed a system in which we “released the potentialities hidden” in a place and its people. This approach shifted design agency by emboldening users to participate in the conception of their environment and repositioning the designers to serve, not as willful artists, but as strategic thinkers—ones who set up the conditions under which architecture is unpredictably and organically, but thoughtfully, grown out of influences external to their control.

Weather Report challenges conventional notions of design agency in three ways. First, it is driven by data. The project is constructed of a frame and an air-filled skin, upon which historic weather data is projected as an abstract, color-coded visualization in constant fluctuation. Second, it is driven by users. Visitors provide memories of weather conditions, which are recorded and played back on the surface of the environment. As such, the installation is under further continuous change in accord with user feedback. Third, it is driven by a plurality of design voices. We took a democratic approach to the project's conception; by focusing on the development of a system and an attitude, rather than a specific esthetic character, the final outcome is novel, surprising, responsive to its context, and continuously dynamic.

This paper will examine how these three drivers (weather data, user interaction, distributed authorship) might contribute unconventionally to a bottom-up, spatialized, data-design approach. We first discuss this in part one of the paper through a description of how each driver specifically informed our project. In part two, we more broadly speculate on the implications of this way of working for the disciplines of architecture, landscape architecture, and computer science. We conclude with a speculation on what the work contributes to discourse around the topic of intersections between data and space.

1.0 WEATHER REPORT PROJECT: driven by data, users, and distributed authorship

1.1 DRIVER 01: Visualization of weather data

The first of the three primary drivers informing Weather Report is weather data. The project was constructed of an inexpensive, off-the-shelf steel tube frame supporting a gridded array of white balloons, upon which we digitally projected historic weather information in the form of a color-coded animation. This produced a rapidly changing environment. Every half-second, one hour's worth of weather data was flashed onto one of the "pixels" (one balloon) of the screen. Read from left to right, the screen communicated weather information about decades, years, months, days, and finally hours, ultimately covering sixty years of recorded history. This yielded a flashing, evolving environment that changed slowly on one end and very rapidly on the other. The experience of visiting the installation is likened to occupying a colorful disco ball.

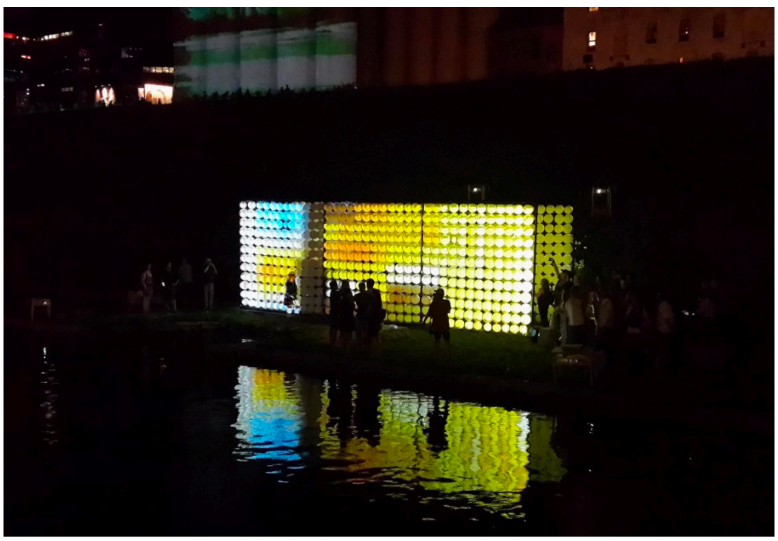

Figure 1: Weather Report at Northern Spark Festival (Authors 2016)

We considered the weather data to be quantitative, and it served as a baseline condition comprised of collected, precise data, to use as a comparative tool for testing the accuracy of users' memories of weather conditions (we will discuss this under "user interaction"). The use of data might suggest a controlled managerial approach to the design of a project, as opposed to an uncontrolled or chance-driven approach. The questions for the team quickly emerged: how could we allow this data, which we did not control, to exert its own control over the project? How could weather data produce a project in which final appearance or form is as controlled by the data as it is by our hands as designers? Our approach was to set up a system in which the data could produce its own environment, where we managed the infrastructure (Figures 2 and 3), but allowed the weather data itself, in its colors, patterns, and motions, to produce its own conditions. The nature of the animation, the patterns of color, the speed of change, the severity of change, were all outside of our control as designers. We likened this to an architect saying that he or she wants a building to be brick, but then allowing different people to pick the color, finish, texture, size, and clay type for each brick in the building. This idea likely sounds unappealing to most architects, however, this was precisely what we did (an approach that is, incidentally, being currently explored by a few critically-recognized architects, like Wang Shu).

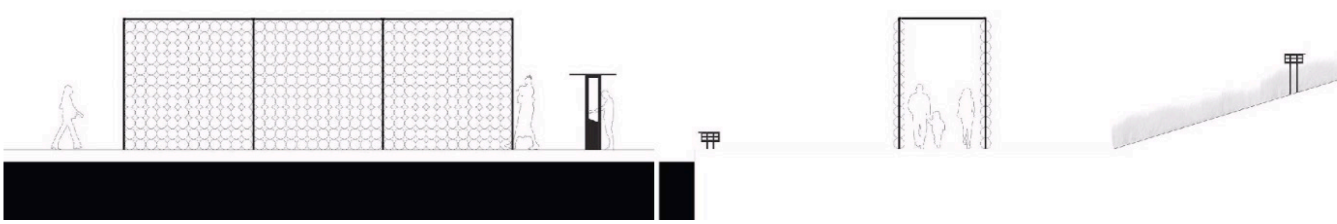

Figure 2: Weather Report elevation and section (Authors 2016)

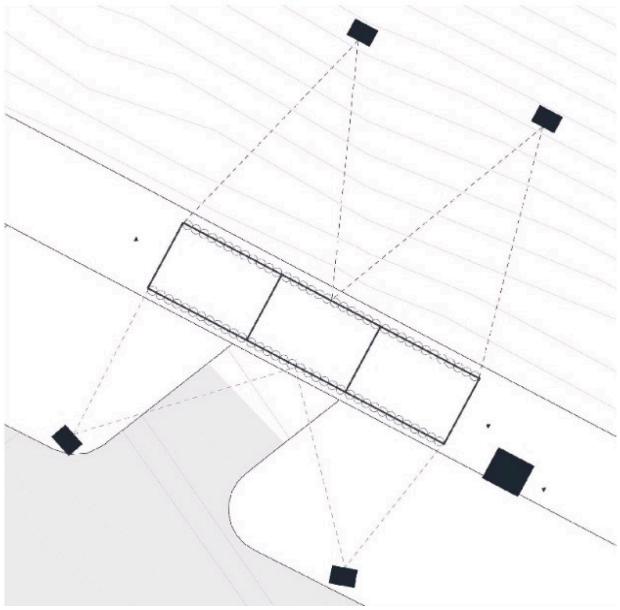

Figure 3: Weather Report plan on Northern Spark Festival site (Authors 2016)

Guiding our methodology and approach to using the collected weather data, our objective was to develop a mapping from data to balloons that would enable visualizing the entire 60-year, hour-by-hour historical weather dataset and that could be mirrored on both sides of the tunnel, with quantitative data visualized on one side and qualitative user data on the other. This was a major challenge, as it required depicting 525,600 data points (60 years x 365 days x 24 hours) each containing five data variables (temperature, rain, snow, wind, cloud cover) in just 432 "pixels" (the balloons are arranged in a 12 x 36 grid of "pixels").

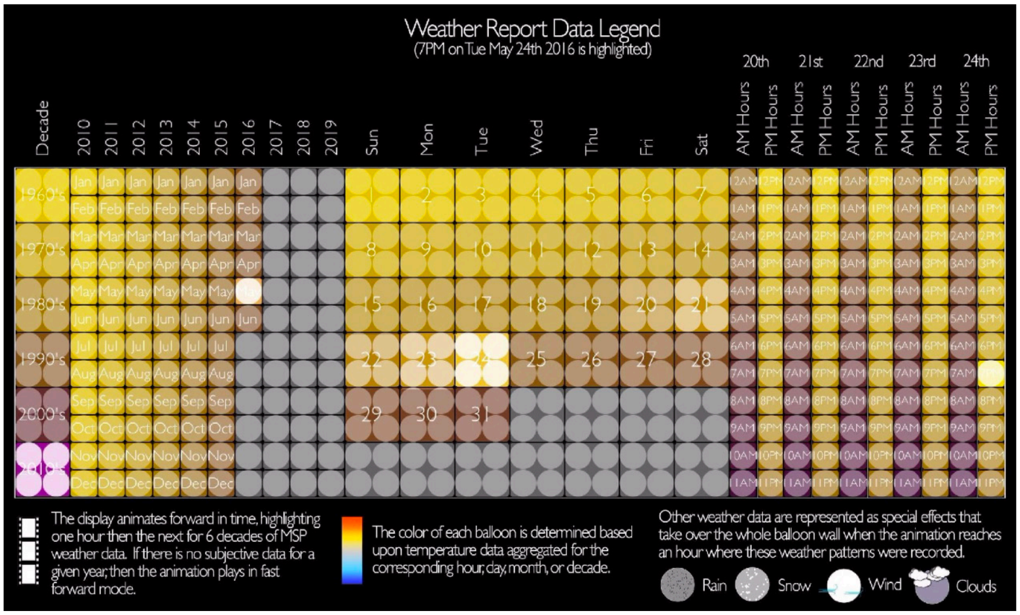

Figure 4: Weather Report Data Legend (Authors 2016)

Our solution, illustrated in Figure 4, is like a weather clock—it uses animation to step through time at a rate of one half-second per one hour of historical weather data. The display is divided into four sections of increasingly fine time scale. From left to right, the balloons represent decades (columns 1-2), each month of each year in the currently highlighted decade (columns 3-12), each day of the currently highlighted month (columns 13-26), and each hour for the 5 days leading up the currently highlighted day (columns 27-36). The visualization always has exactly one hour of data highlighted (in Figure 4, it is 7pm on Tuesday, May 24, 2016), and the highlight moves from one hour to the next each half second. When the highlight reaches the end of the rightmost column, a new column of data (the next 12 hours) is paged in from the right and the display shifts one column to the left. If this brings the display to the next month, then the days-of-the-month display (columns 13-26) is updated accordingly, and so on. Colors are assigned to balloons using the mapping described in Figure 4 based on the historical data for temperature at the corresponding hour in the case of the rightmost section of the display or based on the average temperature in the case of days of the month, months of the year, and decades. The display enables comparison of multi-year trends. For example, change in average temperatures by month can be compared across a decade using columns 3-12.

On the quantitative side of the display, the additional data variables of rain, snow, wind, and cloud cover are visualized as "events". When the display reaches an hour with high values for these variables, then an animated weather event effect is applied for 10 seconds as a semi-transparent overlay on the entire display. For example, if it snowed during the currently highlighted hour, semi-transparent white highlights will fall down like snowflakes across the whole balloon wall, subtly shifting the colors of the underlying temperature visualization. Similarly, high cloud cover introduces an animated overlay of pixelated clouds that drift across the display. Raindrops fall and darken the underlying temperature visualization, and high wind blows any of the other effects rapidly across the screen.

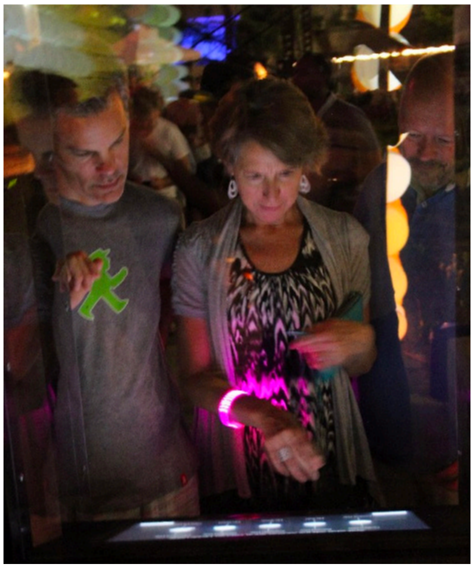

Figure 5: Weather Report user input (Authors 2016)

On the qualitative side of the display, the data are generated by visitors to the space who record values for all five data variables (temperature, rain, snow, wind, and cloud cover) at a specific hour in history using the interface pictured in Figure 5. This makes for a data set with many missing values, and the software fills these in by interpolating between consecutive entries in the subjective historical record. Temperature is visualized using the same mapping as for the quantitative side of the display. However, the animated overlay of weather events is replaced on the subjective side of the display by the visitors' own 10-second animation. This animation is created using a multi-touch sensitive display shown in in Figure 6. Visitors simply draw or act out a weather-related memory directly on top of an image of the balloon wall almost as if they are playing it like an instrument. The resulting animation is displayed once on the wall immediately after it is drawn and then again, whenever the display advances to the hour of the viewer's memory.

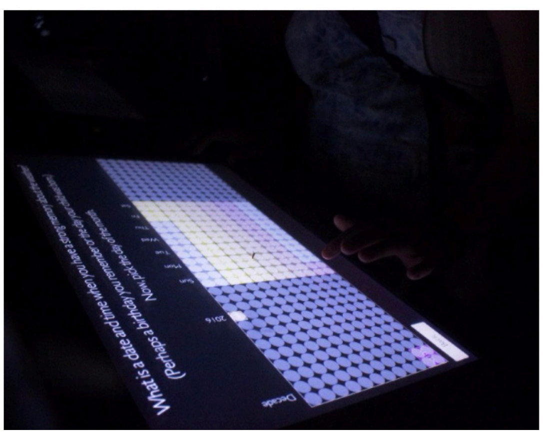

Figure 6: Weather Report interactive screen (Authors 2016)

Upon reflection and critique of our use of the weather data in the Weather Report project, observations emerged to consider in future efforts. First, the legibility of the weather data could be improved. Most participants understood that the project was about weather, but few seemed to understand how time informed the display and that the system could actually be read with a high degree of accuracy. This clarity could be built into the system in a more intuitive way, through the use of a distributed communication strategy via the users' mobile phones, through cues like varying the sizes of the pixels or their distribution, and through auditory cues like a spoken didactic or sound feedback. Second, the scale or coverage area of the weather data could have been more tightly focused to the specific geography of the site. This would render the project more relevant to its location, and help participants connect more directly. Finally, the way the data were visualized could have been more experimental. In its current state, the data is rendered like a bar graph. However, since we were interested in exploring data spatialization, that is, how data can be expanded from its normative two-dimensional or quasi-three-dimensional expression and instead made truly spatial, we saw the reliance on two axes as limiting. Though visitors were able to occupy the data by placing themselves within and around the structure, the reading of the data was still mainly two-dimensional. How might we begin to occupy and understand data that is multi-dimensional from multiple vantage points?

Figure 7: Weather Report balloon "pixels" (Authors 2016)

1.2 DRIVER 02: User Interaction

The second of three primary drivers impacting Weather Report was user interaction. As was described in detail above, the two walls of the installation each communicated a specific kind of data: one, the actual recorded data from the MSP airport, the other, the weather from participants' recollections. Participants occupied the space between these two data streams (Figure 8): one highly precise, the other intuitive/imprecise; one regular and predictable, the other erratic and unpredictable. In the case of user interaction, visitors to the art festival provided the project with data in the form of their memories of the weather on specific dates in the past. Beyond providing these memories, they also "acted out" their weather experiences through the gesture-drawings. Remembered and gestured information was then recorded and periodically replayed on the surface of the environment, as the data visualization cycled through their chosen date.

Figure 8: Weather Report Interior (Authors 2016)

In contrast to the recorded weather data, this set of weather data was subjective, or qualitative. It was derived from the memories of participants, how they felt on a particular day, what their mood was, and how this was impacted by the events of the day. Perhaps a fond memory of a wedding skewed the memory of weather on that day as more pleasant than it actually was, whereas a sad event, like a funeral, was skewed towards occurring on a day they remember as less pleasant than it actually was. So, the challenge for the design team in the case of this subjective information, was not to determine how to relinquish control (we had no control over what was entered into the system), but rather to determine what we could control. Through the development of a standardized set of simple questions, a standard methodology for communicating the answers to those questions, then using a simple visualization strategy that matched the quantitative side of the piece, we achieved this goal. In presenting a system where quantitative information was clearly viewed in contrast to qualitative information, we set up a commentary on the nature of memory as it relates to time and environment. It was rewarding to observe how the participants interacted playfully with the piece throughout the night.

This was another influence beyond our control, and a completely unforeseen dynamic. By placing themselves between the projectors and the surface of the environment, participants created a dynamic, shifting reading of the surface where ghosted movement appeared and disappeared, organically blurring and unsettling the architecture (Figure 9). This produced a condition in which people could further influence the environment through their own, more tactile relationship with the data visualization.

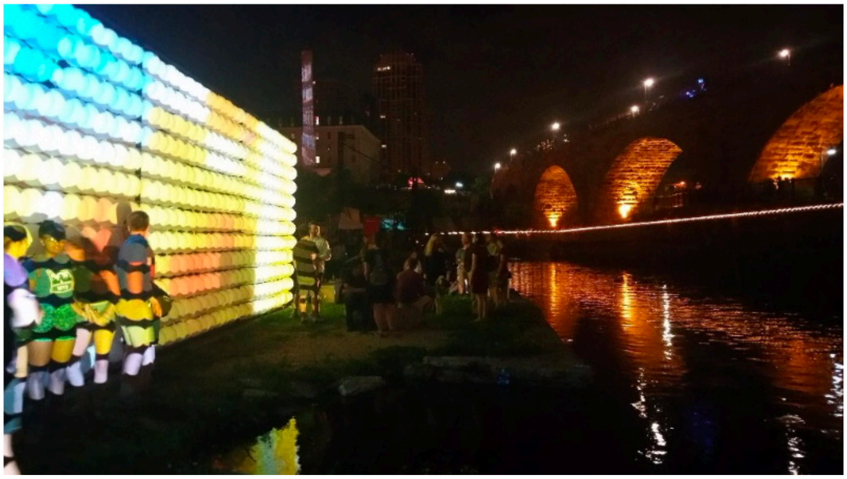

Figure 9: Weather Report exterior showing unanticipated visitor interaction (Authors 2016)

Upon reflection, a number of changes might improve our approach to user interaction. First, the sample size of our user input was small. The input took place during the overnight Northern Spark festival that lasts 8.5 hours from 8:59pm to 5:26am. Because we only provided one touch display, and the queuing line for using it was long, only a small fraction of visitors were able to enter their memories. This might be improved through, again, developing a distributed, mobile-device-based user interface to provide input. In this democratization of data, the more people who can impact its formation and evolution over time, the less control we, as designers, have over it. Further, might the users be allowed, even encouraged, to more broadly impact other aspects of the piece? What if the users were able to change how the data was displayed, what kinds of data were displayed or how color was used? What if users could choose to associate themselves, their names, and where they are from, with their provided data? These questions, and specifically the question of the calculus between control by users versus control by the designers, are ones that this project is only beginning to ask.

1.3 DRIVER 03: Distributed Authorship

The third primary driver impacting Weather Report was its unique form of distributed authorship. In 2013, MINN_LAB was formed by a group of independent architects, designers, and landscape architects, to bring the design community into the annual Northern Spark Festival that was previously driven primarily by the art community. In 2015, the group expanded to include computer scientists through a research collaboration between the College of Design and Computer Science at the University of Minnesota. Weather Report was the third MINN_LAB installation and in response to the 2015 festival theme of Climate Rising, the team decided to address climate effects directly through the experience and spatialization of weather and its related data, and took a democratic approach to the project's conception. It was not produced in the mold of any single team member's previous work, but was instead driven by an approach that purposefully relinquishes design authority. By focusing on the development of a system and an attitude, rather than a specific esthetic character, the final outcome of the work was novel, surprising, responsive to its context, and continuously dynamic.

If weather data was a quantitative driver, and user interaction was a qualitative driver, then our distributed authorship could be described as a decentralized, or bottom-up driver. As designers and researchers, working in situations where we each typically enjoy exclusive authorship and decision-making privileges over our work, the idea that decisions within MINN_LAB would emerge from our collective voices was a challenge. To accomplish this, we have identified a set of ground-rules, outlined below, for working as a team. These rules have emerged organically, over time, but have become an unspoken (until now) set of guidelines to which we adhere.

First, ideas in MINN_LAB can come from anyone at any time. We work with student assistants, outside consultants, and a rotating roster of experts. If someone has an idea, they are free to express it. If it is a good idea, it will be incorporated. Second, we operate with trust and respect. Even when we disagree, we listen respectfully and wait for an opportunity to present a counter-argument. Third, we hold regularly scheduled meetings in which everyone presents prepared drawings and sketches. Drawing and model making is an essential mode of communication (Nicolini, 2012). We draw in preparation for meetings and in meetings, and we find that drawing and modeling circumnavigates linguistic hurdles that emerge from our disparate disciplinary backgrounds. Fourth, the team is fluid and busy, and everyone cannot attend every meeting, so the group that attends a particular meeting is the group that makes important decisions. We do not backtrack or play catch-up, but rather move back and forth from working as a face-to-face to a distributed team (Warner, 2005). Fifth, every project has a leader or manager (Sonnenwald, 1996). This responsibility rotates, but it is important in such a distributed model of authorship that there is one person assigned to overseeing, scheduling, correspondence, and delegation of specific tasks. Lastly, we are driven by strong ideas; we do not move on with developing a project until we have come to a consensus around its central idea. This sometimes makes for slow progress, but good ideas, not speed, are our measure of success.

What is rewarding is that adherence to these rules results in work that no one could have predicted or produced had we authored the projects individually. The process of designing, while slow, messy, and sometimes frustrating, is ultimately rewarding. The work we produce is sophisticated and thoughtful on multiple levels because each of us brings varied priorities and expertise to the work. For example, the tightly choreographed management of the data visualization, with its precisely mapped projection strategy, would not have been present without the computer scientists on our team. The positioning of the piece in the landscape and its relationship to the water would not have been as carefully considered without the landscape architects on the team. The leveraging of everyday, throw-away materials to yield a cleverly crafted, inexpensive armature for the data projection would not have been successfully conceived without the architects on the team. In terms of a reflection or critique of this type of a distributed model, we admit that the MINN_LAB team has never overtly discussed the group's methodology. Through collaborating on this paper, the team has reflected on its methods and outcomes. By its own estimation, the group could undergo more regular check-in's on its established design processes and could more critically evaluate the extent to which these methods are working. Through a similar process by which we evaluate our design work, we could conduct a rigorous and critical analysis of our working process to determine where it is yielding positive results, and where it is not.

2.0 IMPLICATIONS

2.1 Architecture: Implications for the impact of data on architecture

The Internet of Things, an internetworking of physical devices, promises to bring the building industry data-driven intelligence to improve operation, but not necessarily user experience. Smart buildings, in their current state, allow for increased personalization, mobility, sustainability, efficiency, comfort, productivity, etc., through continual connection of local points to an exhaustive cloud. Development is led primarily by hardware and software development within computer science and engineering disciplines, focusing on controllers, gateways, and sensors that provide place-based nodes for inputs and outputs. However, as the number of interconnected components and systems grows, and intelligence is built into more architectural material, like lighting, surfaces, or even structure, there is exciting potential for data to take on a broader, more design-centric, role. And architects can lead this effort.

We explored this possibility with Weather Report. By starting with the individual pixel, a data point (in our case, a simple white balloon) that in its repetition produced a physical volume out of pure data, we were able explore the relationship between data, space, and perception. Data became physical and inhabitable. Our two walls of data straddled a pathway through which festival goers were encouraged to meander, thus inhabiting the space of the data. As such, the project asked the following broader architectural questions: how might data find its way into the surfaces and spaces of a built environment? How might data instrumentalize the Internet of Things in ways that extend beyond the hand-held digital displays and computer screens of our current time and into the material and spatial qualities of architecture itself?

For contemporary precedents of this we can look to a number of architectural projects that explore the potential of the analog building façade to spatialize the territory between the digital pixel, fenestration, light, volume, movement and animation. Solutions range from actual digital screens applied to facades, to more subtle, luminous surfaces incorporated into building skins that evolve and shift in color and intensity, to more spatial, three-dimensional expressions involving projection, volumetric lighting, or even sound. These examples hold the opportunity for open-source, user-generated data fields and other data streams to challenge the control architects typically enjoy over the more static versions of their work. With new bottom-up approaches to data and building appearance, the roles of architects, digital media designers and computer scientists will evolve. These traditionally stand-alone practitioners will collaborate in new ways as the territories of their disciplines continue to merge. The term "smart building" will take on new meaning, referring not just to utility and performance, but also to less measurable, more expressive and intangible qualities we desire in exceptional works of architecture.

2.2 Landscape Architecture: implications for the impact of data on landscape

Weather Report was strategically situated to draw in a larger set of forces within the site context. It was set on the bank of a side channel of the Mississippi within a pedestrian path, at a low point in the topography and infrastructure between a pedestrian bridge over the river and the base of a grassy hill leading up to the edge of a historic cultural district within the downtown. The placement of the installation within this context catalyzed a normally inactive site through light, movement and exchange. The installation drew movement of thousands of people through the newly formed experiential channel, parallel to the Mississippi, capturing the dynamism and complexity of this storied river.

Figure 10: Weather Report citing (Authors 2016)

Weather Report represented an experiment in human interaction with landscape and weather. It deepened our understanding of environmental issues in relationship to people through offering an experience with an educational underlay. Some of the issues it foregrounded included the responsibility of landscapes to communicate and be experienced, the role of public space in the realm of experimentation, the capacity of user interface to confront issues of memory and time, and how landscape can produce new modalities of experience and communication. Weather Report reframes a temporal, indeterminate, and uncontrollable component of the landscape and weather into something both knowable and accessible. It deepens understanding an understanding of weather dynamics through an experience of temporality and flux, foregrounding larger questions around systems and data in landscape architecture.

2.3 Computer Science: implications for experiencing data through its physicalization

Data visualization, although an inherently interdisciplinary endeavor, has a strong academic home and tradition in computer science, where the first computer-mediated data visualizations grew out of the study of computer graphics. Research on data visualization is thriving and expanding, as evidenced by the IEEE VIS conference (ieeevis.org). Work in this community regularly makes use of virtual reality displays, multi-touch and 3D user interfaces, and other emerging forms of computing. Climate data is a frequent topic of exploration, with high-end supercomputer simulations and complex underlying scientific hypotheses driving the development of advanced interactive visualization and visual analytics tools and processes.

Weather Report is novel and exciting to this community for several reasons. First, the combination of human scale, public inhabited space, and outdoor venue for the display produce a radically different experience than what is possible via traditional and even recently emerging computer graphics displays. While many high-end data visualizations do utilize large (e.g., 30 foot) display walls, and virtual reality displays can enable viewers to experience data-driven environments at a human-scale, the ability to do this in a collaborative, public, outdoor setting is novel and exciting. It is a completely different take on scientific visualization. Second, Weather Report is an exciting example of data physicalization (http://dataphys.org), a topic that actually has a rather long history but has not been fully embraced. This is starting to change, at least within the visualization research community, with the widespread availability of 3D printers. The idea is that just as digital computer graphics has helped scientists and others to understand data, data-driven computation might also be used to explain data and/or move from data to insight but in a mode where the output of the computation is a physical, tangible object. To be sure, this is a concept that has been explored by artists for some time, but to do this with large, cutting-edge scientific datasets is an entirely different endeavor. To date, this has been explored almost exclusively at small scales (e.g., 3D printouts of medical data). By translating 60 years of weather data into a physical form that the public can walk through and touch, and by combining the physical representation into a hybrid system that also relies upon digital projection, Weather Report pushes the boundaries of this still-evolving concept of data physicalization.

CONCLUSION

As digital connectivity, robotics, and computation increasingly inform approaches to the design, fabrication, and construction of our built environment, our ability as designers to choreograph flows of information will similarly grow in importance. Just as automation has taken over the assembly of products, it will inevitably take over the assembly of our buildings. While architects have embraced this digitization of materials and assembly, we have barely begun to consider the digitization of space itself. In fact, it is even hard to visualize what the digitization of space, or data physicalization, might look like. With Weather Report, we endeavored to consider this provocative idea, and we call our approach spatio-data design. Far from a science fiction abstraction only accessible through movies like The Matrix, the idea that we might physically occupy and simultaneously affect our endless streams of collected data is now closer than ever to reality. Like many other disciplines, we as architects struggle to understand how to best capitalize on unlimited access to data. While the emergence of increasingly connected, or "smart," buildings point to one strategy, this approach is narrowly utilitarian in nature. With Weather Report, we were interested in exploring the spatial qualities of data, in designing a system that might reveal the reflexive character of data. To do so, we focused on alternative approaches to design process. We purposefully yielded design agency over to the data, to the people who would occupy our work, and to a broad and diverse team of expert collaborators. In this way, the architecture emerged organically from the deftly and carefully crafted management of data flows, instead of from our preconceived attitudes about how we, as designers, thought the space should look and feel. This approach, rather than suggesting removal of control, for us, suggested a reallocation of control. Rather than crafting the physical appearance of our work, we crafted how its physical appearance emerged from the careful and thoughtful choreography of data.

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