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CIMSLAB

Reflections on the Digital Reconstruction of the Chapel of the Convent of Our Lady of the Sacred Heart

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Carleton UNIVERSITY

Reflections on the Digital Reconstruction of the Chapel of the Convent of Our Lady of the Sacred Heart

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Abstract

The 3D digital re-construction and integration of lost and existing architectural and urban artifacts is a decidedly technologically mediated process that requires a familiarity with a wide array of technologies and techniques. It is a complex undertaking that casts one through a variable and heterogeneous digital landscape of map and survey data, orthographic CAD drawings, photographs, 3D non-contact imaging data (laser scanning, photogrammetry), and 3D models.

The reason for the diverse and multiple information sphere is largely due to the intensive visualization requirements, intended use, and long-term applicability of the base data sets that are of interest to architects, heritage preservationists, and urban planners.

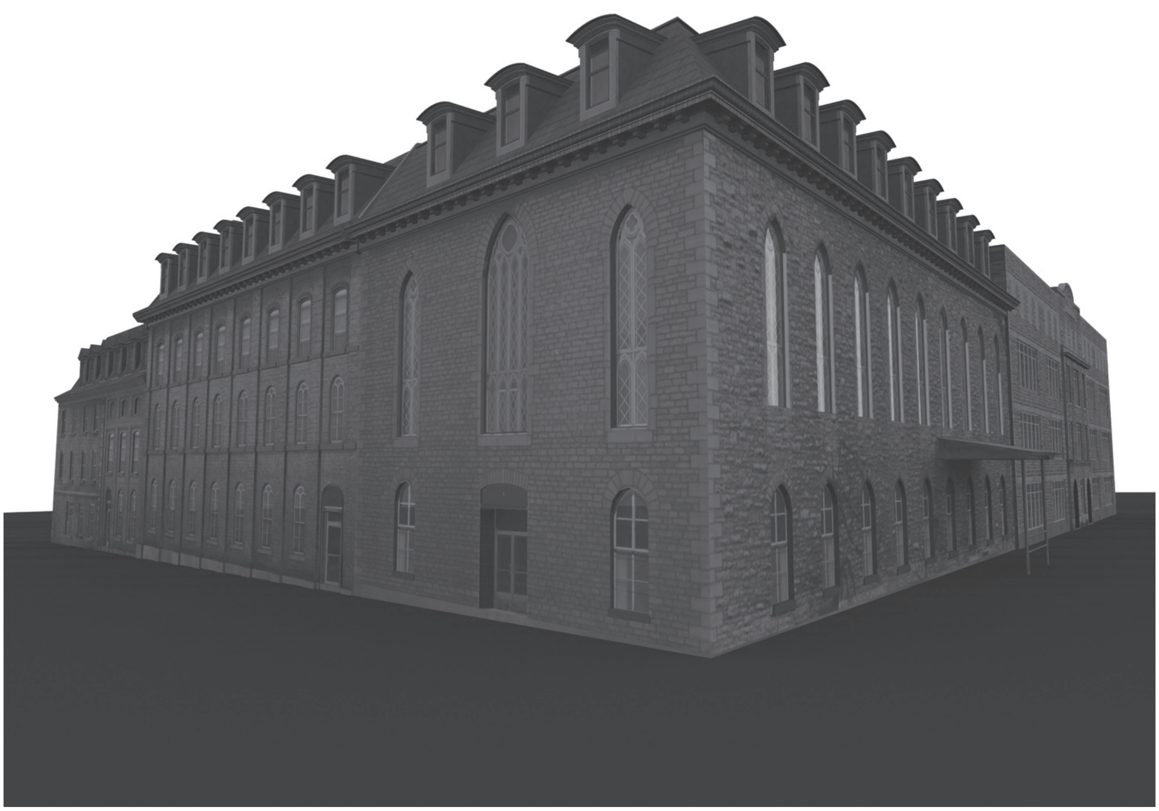
Such a heterogeneous composition of data necessitates a hybrid methodology that is defined by a synthesis of multi-sensor techniques with user-dependent modeling. The further integration of media files generates an augmented and extended set of digital assets capable of being re-purposed and deployed at a number of scales and in a variety of formats.

The following research-creation project attempted to address these two interrelated practicalities: the fusion of heterogeneous data sets and the establishment of a hybrid methodology. It approached these issues through a theoretical lens that explicitly acknowledges the interplay between technological mediation and embodied making.

The objective of the following report is to identify key factors and issues in the decision making process regarding the technologies to employ and the manner by which these processes are negotiated from a technical and creative perspective. *

Project Introduction

The Digital Architectural Reconstruction Program is a Canadian Heritage, New Media Research Network funded program that completed its first year of operation in March 2005. DARP is an initiative of the Carleton Immersive Media Studio (CIMS), an organized research unit within the Carleton University School of Architecture. The research agenda of the interdisciplinary group assumes an intertwining of project-based and applied research that, in the case of



External building views were captured through a combination of photogrammetric and 3-D modeling techniques from archival photographs.

DARP, engages in the digital re-creation of cultural heritage artifacts. The team explores and investigates the creation of virtual and built environments with digital media technologies as they concurrently transform and are transformed by our perceptual and epistemological worlds.

The historic building in question is the Chapel of the Convent of Our Lady of the Sacred Heart (a.k.a. "Rideau Chapel"). The Convent was razed in 1972 but the interior of the Chapel was dismantled and subsequently reassembled in the National Gallery of Canada. The project deliverables included a high-fidelity, interactive rich media presentation of the Rideau Chapel that imaginatively and critically situates it in its historic, conservation, and museum context. The maximum visual fidelity requirements were based on a maximum deployment utilizing a high-performance visualization cluster driving 9.2 million pixel screens. The data set has millions of polygons, multiple media files, high resolution textures, and dynamic lighting.

The project presented here attempted to define a workflow from digital acquisition of extant artifacts to display of high-fidelity 3D models and animations. The explicit intention of the Rideau Chapel project was to digitally re-construct and capture a high resolution, accurate, and interactive model of a lost, historically significant building and urban area for heritage and museological purposes. The fusion of a diverse set of media files, from text, sound, photographic images to animations, QTVR, renderings, and 3D models was achieved both as a means to a greater sophistication of the primary 3D assets and as constitutive of the final multi-media product.

Discursive Context

The theoretical context of the following research considers the technologically mediated character of the creation and meaningful reception of digital artifacts in the realm of cultural heritage practices. The integration of new technologies into any discipline is fundamentally disruptive and puts into motion a de-centering and subsequent re-centering of the process, applicability, and reception of the resultant artifacts. Digital media technologies radically transform the speculative, productive, and constructive landscapes of architecture and require a unique and intensive skill set. Additionally, these very same technologies are reflective of our contemporary conditions that embody new modes of spatiality, materiality of culture, and the ontological and physical world. "New technologies open up new registers of perception, and that calls for a corresponding new visual repertoire. The cultural process in which technology extends our ability to perceive, redistributes social relations, and thereby elicits new visual language and conferral of meanings, is called technological mediation."

Mediated technologies and technique are not necessarily or simply "instrumental" and that they create an opening precisely due to their so-called technical nature. The intent is that logos enables us to become more intelligent and adept with the technè of creating representations and multifarious data sets. Mitchell and Thurtle refer to the "material poiesis of informatics [and to the] moments when information and flesh co-constitute one another. Understanding these moments allows us to illuminate the specific ways that we perform the transformation from the virtual world of information to the actual world of flesh and bone, as well as the implications of this moment for human biological existence (the species body), communal interactions (the social body), and the accessing and transformation of shared memory (the body of knowledge). [W]e have the capabilities to use informational technologies to generate new forms of fleshy experience."

Information technologies are not simply distinct modes of instrumental thought that overlay the body as merely their structural frame of reference. There is no one body and thus not one stable notion that can ground all else in the realm of artifice. "[Phenomenology] too often reifies the body as the 'zero point' of sense experience and does little to help us understand the integrity of mediated experience in linking and transforming bodily interaction. The cultural dimensions of mediated experience end up as a problem that begs explanation, rather than being understood as a reverberant and active part of embodied experience."

The virtual environment of the type sought here are a unique symbiosis of visual fidelity and abstraction that are "real ideations. They may be experienced as real but they are neither tangible nor actual. … [The distance between spectator and her memory] is the space of 'metaxis': the operation of the imagination which connects the perceptual environment with the virtual and abstract world of meanings which over-code our perception."

Lastly, the production of content was a practical means to gain skill sets while simultaneously engaging in applied research around a select set of new media technologies and techniques. Cultural content creation greatly determines and is determined by technological innovation and advance in applied research. Kockelkoren uses the term technoèsis to describe the intertwining of (technologically) mediated experience and the assignment of meaning. "The capacity of technology to open up reality and give shape to culture has been called technoèsis [which] stresses the mediated character of every act of conferring and understanding meaning. … The formation of artistic images and technological design evolve in parallel. Images, technologies and even scientific theories emerge in a social process, and that process is not marked by monocausality. [Thus, it is preferable] to speak of the co-evolution of technological design, the formation of images and the conferral of meaning – in other words, technoèsis."

Data Fusion

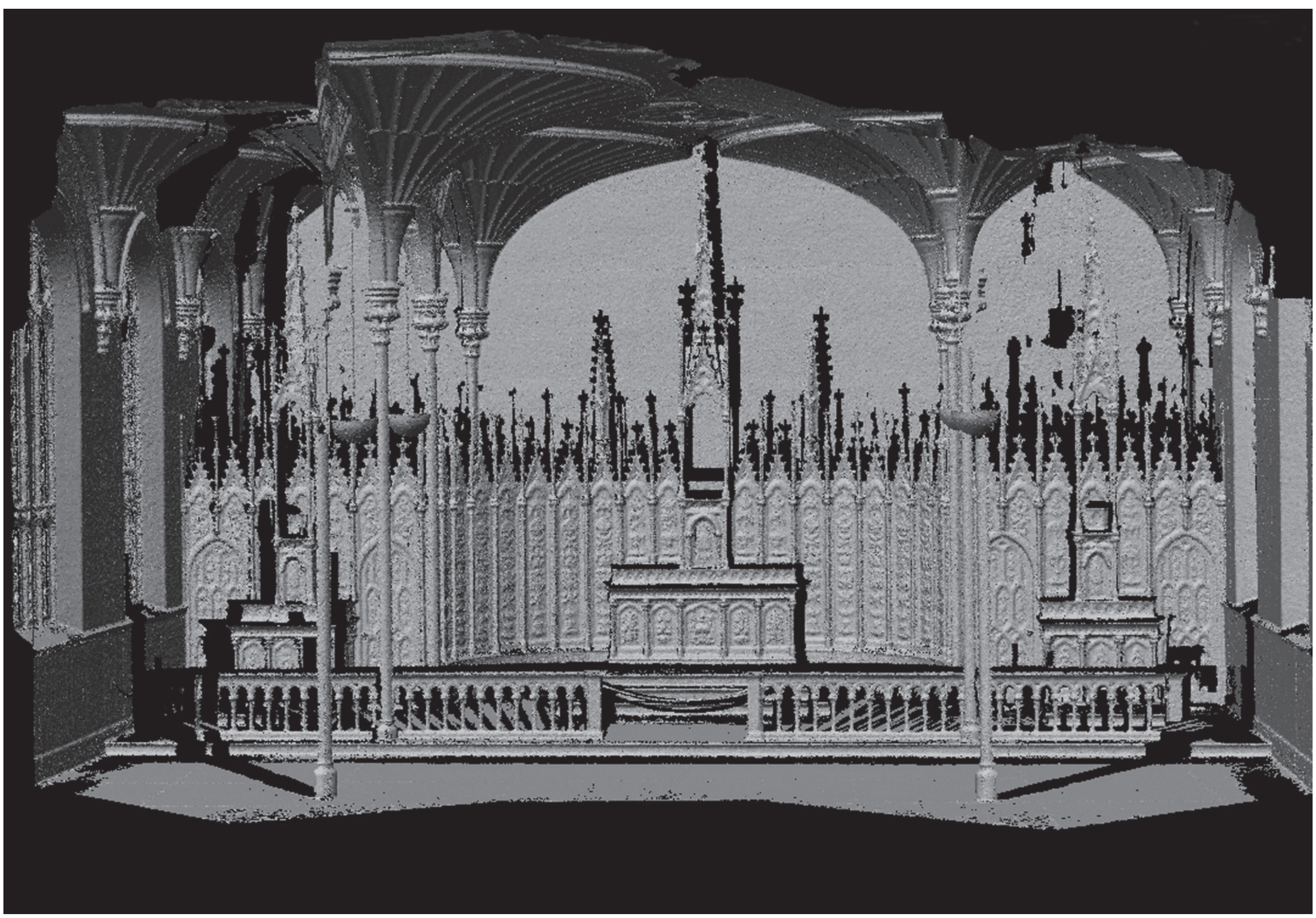
Multi-sensor, multimodal 3D digitization of urban and architectural environments holds immense creative, analytic, and visual-rhetorical possibilities for architects and urban designers. With current advances in laser scanning, photogrammetry, and GIS-related technologies the integration of 3D imaging techniques within existing workflows has become a viable and effective solution. The benefits of utilizing multi-sensor data in cultural heritage and existing conditions documentation allow for architects to powerfully situate design proposals within accurate and visually convincing contexts.

With this said, the use and integration of multi-sensor technologies, such as laser scanning and photogrammetry, with traditional modeling, texturing, and animation is not a seamless enterprise. Factors that must be considered from the outset are the tolerances and thresholds for metric accuracy, visual fidelity, and deployment. These quantitative and qualitative measures are fundamentally of a different nature in this context than that of geographers, infrastructure planners and analysts, engineers, and facility managers who are more commonly implicated with these 3D non-contact imaging techniques. Digital assets conform to type specific thresholds of precision and visual fidelity depending upon their use and integration into an overall production and deployment pipeline that steadfastly corresponds to disciplinary skill sets, expertise, and intentions.

A key factor in determining the data required is a balance between the function of the assets for the application in question and the re-purposing and long-term use in other contexts. Whereas in most situations such as engineering analysis or surveying applications the end users and applicability of such data are relatively speaking specialized and limited, in the case of architectural models the stakeholders range from those within the architectural-engineering-construction (AEC) professions to city officials and the general public. Additionally, the metric tolerances range from urban (meters) to Computerized Numerical Control (CNC) fabrication of physical artifacts (sub-millimeter) thus requiring differing technologies for corresponding intended end use.

Thus, visual fidelity requirements, metric accuracy, and the integration of multiple media types are the primary considerations when determining the sensor technologies to be used and methodologies to be employed. The efficiency of manipulation and high-performance visualization capabilities must be weighed. A strategic initial acquisition of base data allows the information to be re-purposed and does not require re-visiting the physical site.

The process for the Rideau Chapel combined a multi-sensor approach with conventional 3D modeling, texturing, and animation that included photogrammetry techniques (ShapeCapture), time-of-flight laser scan data (Optech ILRIS-3D LiDAR scanner) and close-range scan data (ShapeGrabber® PLM600). Laser scans of the Chapel's interior (extant in National Gallery of Canada), augmented with photogrammetric three-dimensional models created from archived drawings and photographs, enabled the re-construction of the context — both the lost and remaining buildings — in a superior visual and historical fidelity.



A time-of-flight laser scan of Rideau Chapel (top) was done using an Optech ILRIS-3D LiDAR scanner with data conversion by Northway Photomap. A fusion of datasets from laser scans, photogrammetry (ShapeCapture software), 3-D modeling/texturing (FormZ and Maya software) created another image (bottom).

The fusion of multiple, varied data sets accomplished two objectives. Firstly, differing data sets were cross-referenced to verify and make the overall 3D model more robust in terms of precision and depth of information with respect to the metric tolerances and visual fidelity required. Secondly, each data set retained their autonomy and augmented the overall understanding of the artifact in a larger historical, social, artistic context.

CIMSp: 3D Imaging and Modeling Protocol

The second applied research goal was to develop a 3D imaging and modeling protocol (CIMSp) that incorporates multi-sensor technologies with modeling and rendering techniques through a process of interpolation between a heterogeneous set of existing photographic, physical, and 2D documentation as described above. CIMSp is intended to define a disciplined yet sufficiently contingent "best practices" process that channels information and resolves procedural and technical hurdles in situations where integration of 3D non-contact imaging and user-dependent 3D modeling of non-extant (proposed or lost) architectural conditions is desired.

As mentioned, the intention of project was to digitally re-construct a lost heritage building from a partially existing architectural artifact and existing orthographic and photographic documentation. The resulting digital object indicates a scaleable multi-sensor 3D imaging and modeling approach that is applicable to architectural, urban and heritage decision making; physical artifact re-construction; and virtual event construction relevant to cultural venues, entertainment, education, and design proposal discussions. The initial acquisition accommodates a high fidelity and precise output thus allowing for the decimation of the resultant data for web and screen based output.

The modus operandi implemented is a multi-layered and hybrid approach that recognizes the interplay between human scale and perception, visualization and abstraction of data, and geometric accuracy. As a general benchmark, the metric accuracy of data sets in regard to existing conditions largely conforms to the phenomenological scale of the artifact in question. For example, in the case of a building envelope or room within a building the accuracy has a larger tolerance than that of an object within a room or architectural detail such a bas relief or carved molding. The overall dimensioning of a building can be accurately obtained by a hybrid methodology of traditional user-dependent 3D modeling and photogrammetry and/or ortho-rectified photomapping if a larger urban context is required.

In the protocol developed here the primary layer captures

A detailed interior illustrates a fusion of datasets from laser scans, photogrammetry and 3-D modeling/texturing. Atmospheric lighting in the rendering environment adds a greater degree of realism.

the overall geometry of the artifact including large-scale details and urban context. The secondary layer uses survey data from the primary layer to generate more specific geometries. The tertiary layer utilizes laser-scan data to capture sub-millimetric geometries. This layered approach is necessary to ensure a practical balance between a high degree of accuracy and efficiency. The layers are structured in degrees on increasing geometric and textural accuracy and can be followed up to any point, from the macroscopic views of the primary layer to the sub-millimetric accuracy of the tertiary layer.
The benefit of this approach is twofold. It allows for the work to be divided easily between several groups and it demarcates definitive milestones to occur throughout the digitization process. Upon completion of the objectives in the primary layer for example, a completed model can be generated that contains all the major geometric details and a large amount of survey data. Completion of the objectives in the secondary layer provides a model with a significantly greater refinement and accuracy. Completion of the objectives in the tertiary layer provides a model with exponentially greater detail.

The demands of accuracy and fidelity asserted for architectural applications determine the thresholds to be achieved thus indicating the preferred sensor technology. To accommodate for the differing scales from urban to CNC milling output the aforementioned layers must employ technologies that can be integrated while respecting the requirements of the immediate application. By utilizing multi-sensor 3D non-contact imaging techniques from close range and time-of-flight laser scanning to photogrammetry alongside 3D modeling the desired accuracy and range of applicability was achieved.

Issues of efficiency are dependent upon practical knowledge, skill sets, and the metric tolerances specific to the intended output. In the case of architects user dependent 3D modeling is often more effective than photogrammetry techniques. Photogrammetry proved to be dimensionally more accurate but inadequate or inefficient in acquiring complex geometries as compared to user-dependent modeling. Therefore, the accuracy of the Chapel itself was confirmed by using photogrammetry techniques and derived models as templates and overlays with 3D modeling which allowed for more efficient complex modeling. This process confirmed the inaccuracy of existing two-dimensional drawings that are typically the basis for current 3D digital reconstruction.

A LIDAR time-of-flight scan was taken of the existing space but it was determined that the additional accuracy was of little benefit to the model over the photogrammetry-modeling hybrid methodology. Metric tolerances are such that the cost-benefit of laser scanning entire structures over 3D modeling is not typically justifiable unless access to pre-existing data sets is available. The artifact was sufficiently rectilinear for this process to work but there are certain cases, particularly cultural heritage, where point cloud data is necessary due to the amorphous geometry of existing conditions.

Close-range scanning was used to capture intricate carving on the altar. The optimization of certain data sets required a process of decimation but in order to meet goals in which high-resolution is required, the original data set must be of superior quality for this re-purposing to occur. The obtained point cloud data can be used for precise physical fabrication of the details on a CNC milling machine to restore or replace lost artifacts or for authentification purposes. In several cases, the knowledge and ability to hand fabricate historically significant artifacts has been lost thus precise documentation through laser scanning is crucial.

Conclusion

The fusion of the various media contributed to the creative process in terms of cross-reference and metric verification while the individual data sets retained their autonomy for specific application. The ontological status of work is a value that must be weighed with the effort and resources committed to acquire the data. Lastly, the inclusion of various files in the interaction with the material and content asserted their value as "new forms of fleshy experience" in the experience of the rich media presentation.

The resultant model is duly accurate and visually sophisticated to be utilized for design and re-construction purposes as well as for cultural heritage and museological presentation. Due to the integration of multi sensor technologies, the resulting digital artifact allows for a multi-modal output including high resolution print media to interactive 3D content and animations deployed on a high-performance visualization cluster for high fidelity and immersive environment output. Decimation of the high-fidelity assets was accomplished for rich media DVD, web and standard screen deployment.

The demands from the architectural and urban design industries place variable and diverse requirements on sensor technology and associated 3D digitization techniques. The requisite skill sets and proficiencies of the discipline and disciplinary tolerances need to be considered in order to determine and customize the tools utilized. The ease and accessibility of technologies must be appropriate and they must be integrated into existing workflows. If the techniques and technology responds to these parameters a significant reduction in site surveying, construction, cost estimating is possible in addition to the cultural heritage and creative possibilities in design activity.

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Endnotes

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The Rideau Chapel project was supported and funded through the Canadian Heritage, New Media Research Network fund with additional funding from Carleton University Office of the Vice President Research, Faculty of Engineering and Design, Faculty of Graduate Studies, and the School of Architecture.

1 This is an ongoing research project testing and developing a beta High Performance Visualization solution with IBM Research, Deep Computing Visualization group.

2 Kockelkoran 2003, 8.
3 Heidegger 1977; Ellul 1965; Perez-Gomez 1982; Perez-Gomez and Pelletier 1997; Veseley 2004.

4 Mitchell and Thurtle 2004, 8.

5 Mitchell and Thurtle 2004, 5.

6 Shields 2003, 38-9.

7 Applied research was carried forth in collaboration with strategic industry and institutional research partners such as IBM; Alias Systems; the National Research Council of Canada, Institute of Information Technology, Visual Information technology group; Communications Research Centre of Canada. These research results will not be discussed at length here.

8 It is assumed that the content, tool, epistemological, and speculative realms are consubstantial. The research proceeds in a manner as "to have a say" in the tools employed.

List of Captions

Fig 1: External building views were captured through a combination of photogrammetric and 3-D modeling techniques from two archival photographs.

Fig 2: A time-of-flight laser scan of Rideau Chapel (top) was done using an Optech ILRIS-3D LiDAR scanner with data conversion by Northway Photomap. A fusion of datasets from laser scans, photogrammetry (ShapeCapture software), 3-D modeling/texturing (FormZ and Maya software) created another image (bottom).

Fig 3: A detailed interior illustrates a fusion of datasets from laser scans, photogrammetry and 3-D modeling/texturing. Atmospheric lighting in the rendering environment adds a greater degree of realism.