EFFECT OF CONTEXTUAL CONDITIONS ON THE PERFORMANCE OF MEASURED SURVEY METHODS

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Introduction

Measured surveys are a universal form of heritage resource documentation. Historic surveyors, photogrammetrists, and governmental recording program workers carry out field measurement surveys on heritage buildings and produce "measured" drawings for preservation purposes as diverse as the needs of documentation users. They employ a variety of survey methods, such as hand measurement, rectified photography, digital techniques[1], and others.

Technical performances of field survey methods are concerns of documentation providers[2]. From a technical viewpoint, survey planners recognize differences in method performances in accuracy, thoroughness, and rate. Hand measurement, for example, performs well when the surveyed building parts are accessible and plain. Similarly, site rectifiedphotography performs well when the space between camera station and surveyed surface is clear and unobstructed. Both methods, then, improve in performance with increasing degrees of adequate contextual conditions—until performance reaches capacity. "Capacity" performance is optimal performance—obtained only under the most favorable contextual conditions.

Optimal performance and actual performance are useful notions in assessing the effect of contextual conditions on method performance. How many contextual conditions are there? How can we quantify the effect of each condition on methods performance—accuracy, thoroughness, or rate performance? For example: how can we reasonably determine the effect of the building height (a contextual condition) on the resulting accuracy (performance attribute) of hand measurement surveys?

This study proposes a framework for assessing the effect of field contextual conditions (or factors) on the performance of heritage building measured survey methods. The study targets the following objectives:

- o Defining survey methods and methods performances
- o Identifying contextual factors associated with building, site, and climate
- o Examining the effect of contextual factors on methodstechnical performances

Survey Methods and Methods Performances

Survey Methods

Measured survey methods range widely, from the primitive practice of pacing distances to measurements by digital computer models. New methods emerge every so often, and it's hard to "remain informed about all alternatives."[3] Survey methods, however, are not categorically well defined. Further, a method is often complemented with other techniques to complete the task.[4] This study approaches methods in the context of the first phase of survey projects, data collection. When planning a survey project, method characteristics are naturally reviewed in comparative terms. We will briefly define hand measurement, estimation practices, and site rectified photography methods.

Hand Measurement. Probably the conventional method used most[5], hand measurement utilizes simple equipment, including tools long established in the land surveying field such as measuring tape, folding rule, bubble level, and plumb bob. Other items include sketching pad, ladder, camera and film or digital camera. Although capable of producing accurate results, hand measurement is applicable only to areas of hand's reach.

Estimation Practices. These practices have different degrees of refinement. Examples include:

- o Distance pacing and construction unit counting
- o Triangular methods, where a triangle is formed, aided by sun shade or eye sighting, and solved
- o Proportion-based techniques, such as balanced sketches and manipulated photographs in which dimensions are deducted based on the proportional relationship of dimensions in the sketch or photograph

Estimation technique accuracies are, at best, approximate. Requiring modest skill and resource requirement, they are superior to hand measurement in accessibility and speed.

Rectified Photography. This method employs single photographs to document plain surfaces, such as exterior façades or painted ceilings. It builds on the dimensional proportionality of different elements (i.e., window height and building height) in scaled photographs to determine actual dimensions on the subject.

To achieve that, geometric parallelism between the image plane in the camera and the surface plain is established on site. Only a few building elements are actually measured on site to establish photographic scale.

Rectified photography surveys are capable of distinct thoroughness and accuracy. This is true because photographs record scenes comprehensively and meticulous site photography setups assure validity of measurement. However, this method is demanding in expertise and equipment.

Method Performance Attributes

Performance is a measure of accomplishment. Meanings for the technical attributes accuracy, thoroughness, and rate are further explained below. Method accuracy connotes the degree of the conformity of measurements to their true value.[6] Project required-accuracy level, on the other hand, is often a function of the interrelatedness of subject significance[7] and survey purpose. An authentic restoration survey for a highly significant building would require a high degree of accuracy.

Thoroughness is a degree of method capacity for recording survey information with abundance and ease. While in hand surveys the dimensional and angular measurement operations are selective and confined to accessible parts, the scope of measurable targets in rectified photography can be all-inclusive. Consequently, rectified photography has a thoroughness edge. Similar to required accuracy, project-required thoroughness level is also often a function of interrelatedness of subject significance and survey purpose.

Rate performance is the pace at which a survey is driven to completion. In comparative terms, hand measurement operations go at a slower rate than rectified photography, although rectified photography setup procedures are time consuming. A Required survey rate is modified, among other things, by urgency level of survey.

Contextual Factors

This study identifies the field contextual conditions that affect performance of survey methods—to lay a basis for determining the effect of each condition on the performance of methods. Typically, the field survey progresses from one building part to the next, for example from the front elevation to a side elevation. Therefore, a building "part" is the appropriate scope of the subject to consider.

Contextual factors come under building, site, and climate categories:

- o The building factors category pertains to the physical and dimensional characteristics of the subject and comprises five factors.
- o The site factors category pertains to the physical and dimensional characteristics of the site where the subject building is located, and comprises three factors.
- o The climatic factors category pertains to micro-climatic characteristics of the site and comprises five factors.

Individual factors are highlighted below under their respective categories. A prefix of category affiliation leads to factor description.

Building Factors Category

What follows is a list of building factors (BF):

BF1. Height of building part: a measure of how much the building departs from one-story height

BF2. Size of building part: a measure of how much the size of the building part exceeds that of the main elevation for a small house

BF3. Condition of building part: a measure of how much the building part can safely[8] support movement of crew and survey operations

BF 4. Complexity of building part surfaces: a measure of how much the building part surfaces depart from that of a plain and smooth surface

BF 5. Concealment of building part surfaces: a measure of how much the concealment of the building part surfaces departs from that of an unconcealed, exposed surface

Site Factors Category

What follows is a list of site factors (SF):

SF1. Size of property: a measure of how much the size of the property and surrounding grounds departs from that which affords suitable distance photography and sighting

SF2. Topography of site: a measure of how much the topography of the site departs from that of a level and plain site

SF3. Obstructions on site (trees, poles, etc.): a measure of how much obstruction conditions on site depart from that of no-obstruction conditions

Climate Factors Category

What follows is a list of climatic factors (CF):

CF1. Temperature: a measure of how much the expected temperature during fieldwork would depart from that of a moderate temperature

CF2. Humidity: a measure of how much the expected humidity during fieldwork would depart from that of a moderate humidity

CF3. Wind: a measure of how much the expected wind speed during fieldwork would depart from that of a moderate wind speed

CF4. Precipitation: a measure of how much the expected precipitation during fieldwork would depart from that of a no-precipitation condition

CF5. Daylight: a measure of how much the expected daylight during field work would depart from that sufficient for performing photographic tasks and visual inspection

Effect of Contextual Factors

Effect Scales for Contextual Factors

This study now examines how contextual factors influence the performance of survey methods in accuracy, thoroughness, and rate. The effect of contextual factors materializes at varying degrees depending on varying conditions under each factor. For illustration, consider the building factor BF4: complexity of building part surfaces. A range for varying conditions under this factor could be plain surface, somewhat complex surface, and complex surface. This range is actually a scale of conditions arranged from the least severe (having the least effect on method performance) to most severe (having the most effect). If contextual severity and its associated degree of effect is labeled with the word "class," the *effect scale* will be as follows:

	Contextual Severity	Degree of Effect
Class 1	Plain surface	No effect
Class 2	Somewhat complex surface	Measurable effect
Class 3	Complex surface	Major effect

The very definition of the building factor BF4, represented by Class 1: plain surface, incorporates a reference for the scale. This interpretation makes this class condition the most favorable condition that permits optimal performance; the remaining two conditions will yield less than optimal, or actual, performances.

The analysis for developing BF 4 effect scale applies to developing effect scales for all factors—thirteen in number. To make the point, effect scales of only two other factors, one each from the remaining contextual factor categories, are presented below:

o SF3. Obstructions on site (trees, poles, etc.)

	Contextual Severity	Degree of Effect
Class 1	No obstruction conditions	No effect
Class 2	Somewhat obstruction conditions	Measurable effect
Class 3	Obstruction conditions	Major effect

o CF5. Daylight

	Contextual Severity	Degree of Effect
Class 1	Sufficient	No effect
Class 2	Somewhat insufficient	Measurable effect
Class3	Insufficient	Major effect

Assessing Effect of Contextual Factors

The features discussed so far that are of particular interest to this section include: a) three survey methods, b) three performance attributes, and c) thirteen contextual factors.

How can these multiple features be brought to bear on the evaluation of methods performances? We propose a simplified measured survey scenario with isolated elements:

- o Subject: the front elevation (part) of building
- o Method: hand measurement
- o Contextual factor: complexity of surfaces (BF4)
- o Performance attribute: accuracy

The question now reduces to what is the effect of the complexity of the front elevation surfaces (contextual condition) on the resulting accuracy (performance attribute) of the hand measurement method? If the number of methods is modified into three (hand measuring (HM), estimation practices (EP), and rectified photography(RP)), the scenario question is as follows: What is the effect of the complexity of the front elevation surfaces on the resulting accuracies of the three survey methods?

Answering the question begins with quantifying the degrees of effect of the BF4 effect scale developed previously, as shown in the insert table below. Quantification is based on ranking accuracy performances of the three methods. Therefore, 1, 2, or 3 are the numerical form of method performance rankings. For example, Class 2 raw indicates hand measurement and rectified photography perform about equally and ahead of estimation practices. Deciding on the rankings of methods performances is based primarily on measured survey expertise. Once rankings are fixed, the table information becomes standard for accuracy performance of methods under the contextual factor "complexity of part surfaces."

	HM	EP	RP
Class 1: Plain surface	0	0	0
Class 2: Somewhat complex surface	1	3	1
Class 3: Complex surface	2	3	1

Using the process followed in developing standards for accuracy performance under the effect of contextual factor BF4, we will obtain a total of thirteen sets of corresponding standards, one set per contextual factor. By the same token, we will obtain thirteen sets of standards for thoroughness performance of methods and thirteen sets of standards for rate performance of methods.

Reflections and Comments

The following statements reflect on the objectives of the study. An overall summary of conclusions follows.

Related to Survey Methods and Methods Performances

Identities of measured survey methods are far from fixed. Unrelenting technological advancements add to this characteristic. Because of their nature, some methods, like estimation practices, witness little change. On the other hand, others, like rectified photography, assimilated much from the digital stock—as did other photogrammetric approaches. Building on photographs as data plane, computer visualization and modeling present enormous potential for novel measured survey applications. However, this study discussing only three method types was sufficient to bring out enough of method identity distinctiveness to support the study objectives.

Meanings for the isolated accuracy, thoroughness, and rate performance attributes remain somewhat vague, and assigning absolute values to them is rather difficult. They definitely become more useful when evaluated in comparative terms, as has been done in this study.

Related to Contextual Factors

Classifying the factors into building, site, and climate categories in and by itself is adequate. However, the population of factors under each category accepts adjustment. For example, the climatic factors, CF1, temperature and CF2, humidity, might better be combined into one factor based on fuller understanding of the effect of temperature and humidity on the human body. Further, definitions of some individual factors are not robust enough, as in the building factor BF2 that relates the size of the building part to the size of the main elevation of a "small house."

Related to Effect of Contextual Factors

Designing effect scales with three classes is adequate. Class 1 (in which contextual severity does not exist, and thus has no effect) serves as a threshold reference to the remaining classes. Adding extra classes to the scale would be problematic refinement because assigning effect values to increased member of conditions is impractical.

Establishing standards for the effect of contextual factors on comparative basis is expedient and so is the adopted performance ranking of the (three) methods. The rank numerical values 1, 2, or 3 reflect the cardinal assessment intent, which, in turn, further the argument.

Overall Comments

The study has established a framework for assessing the effect of field contextual conditions on the technical performance of heritage building measured survey methods. The framework's general structure is sound in its master components and component relationships. However, some lower level ingredients are vague in their construct. Further, subjectivity of information needed for assessment is evident. Comparative treatment of methods helps alleviate this problem.

The results of this study provide opportunities for further research on aspects of the study or in extending it. Examples of the first include survey methods defining parameters and basis for comparative methods performance ranking. Opportunities for extending the study lie in establishing a procedure for selecting methods for survey projects.

Notes

[1] See Derek Worthing and John Councell, "Issues Arising from Computer-Based Recording of Heritage Sites," *Structural Survey* 17, No. 4 (1999): 200.

[2] Current information on providers and users relationship is articulated in the session Bridging the Gap Between the Information User and the Information Provider, CIPA 2001 International Symposium Surveying and Documentation of Historic Buildings, Monuments, Sites - Traditional and Modern Methods, Potsdam, Germany. See: Robin Letellier, "Introduction to the 'Bridging the Gap' Concept"; Francois Leblanc, "Proposed Partnership between ICOMOS, CIPA and the Getty Conservation Institute; and, Diora Solar, "Bridging the Gap: Why? What Is the Problem?" http://cipa.icomos.org/papers/2001-.htm, cited 27 August 2002.

[3] W. Boehler and G. Heinz"Documentation, Surveying, Photogrammetry" CIPA 1999 International Symposium, October 1999, Olinda, Brazil, http://cipa.icomos.org/papers/index.html, cited 27 August 2002.

[4] Historic American Engineering Record, *Recording Historic Structures & Sites for the Historic American Engineeering Record*, (Washington, D.C.: U.S. Department of the Interior, National Park Service, 1994), 45.

[5] Antonio Almagro Gorbea, "Photogrammetry for Everybody," CIPA 1999 International Symposium, October 1999, Olinda, Brazil, http://cipa.icomos.org/papers/index.html, cited 27 August 2002.

[6] R. E. Paul, *Basic Metric Surveying*, 3rd ed. (London: Butterworths, 1985), 12.

[7] According to the Historic American Building Survey, "documentation shall explicate and illustrate what is significant and valuable" about the subject. HABS/HAER, *Secretary of the Interior's Standards for Architectural and Engineering Documentation* (Washington, D.C.: U.S. Department of the Interior, National Park Service, 1990), 1.

[8] Historic American Engineering Record interestingly discussed seven areas of safety concerns, 51-52.

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