AN APPLICATION OF PHOTOGRAMMETRY MEASURING TECHNOLOGY TO PARAMETRIC MODELING OF KOREAN TRADITIONAL WOODEN STRUCTURE

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Abstract. To construct a 3D parametric model of Korean traditional wooden structure, the fundamental process is to obtain the dimensions of each building. An application of measuring high technology helps this process accomplished more efficiently. However PhotoModeler is a photogrammetric program to measure the dimension using photographs. The information derived from PhotoModeler is used to clarify the design rule inherent in a Korean traditional mansion type building - UnHyun Palace.

1. Introduction

The objective of this research is to propose a method of constructing a 3D parametric model of Korean traditional wooden structure. One of the fundamental processes of this research is to obtain the dimensions of each building by using PhotoModeler.

PhotoModeler is a photogrammetric program that extracts 3D models and dimensions from 2D photographs. Its official name is "Soft-copy analytic close-range convergent photogrammetric software system". If we have the photographs that include the parts we need to measure, PhotoModeler not only shows a 3D image of the part but also gives the dimensions. This research is to apply this program to measure the dimensions of Korean traditional building. The scope of this research is restricted within Korean traditional mansion type building.

Among many Korean traditional mansions, the UnHyun palace is the research case. This building is a representative building of late 19 C mansion type building and a good example to apply PhotoModeler. Even though we know the real measurements of this building, we picked this

building to compare the measurement obtained through the program with the real measurement.

2. Photomodeler for Measurement of Building Dimensions

2.1. TAKING PHOTOS

To use PhotoModeler, one or more photographs of a scene or an object are needed. Photographs are a key data for this program. It can be photos taken of the actual building or a demolished building. Since the structure of traditional Korean buildings is normally exposed, we can take photos in almost every aspect.

2.2. OPERATION IN PHOTOMODELER

The following operation shows how to measure dimensions of a purlin, a column top-tie and a column by using 4 photographs. These components are the principal components of traditional Korean mansion type structure.

The photographs are displayed on the screen. Afterwards, the operator should mark the outer shape of the component with lines or curves. PhotoModeler then combines the photographs and locates the marked features in three dimensions. The marks become accurate measured points, lines, curves, cylinders or polygons in a single unified 3D space. *Figure 1.* shows a 3D model of a purlin and a column obtained by using PhotoModeler.

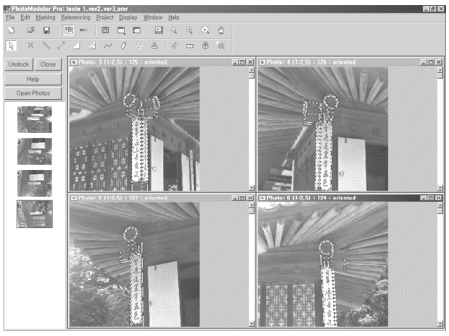

Figure 1. operation of Photomodeler

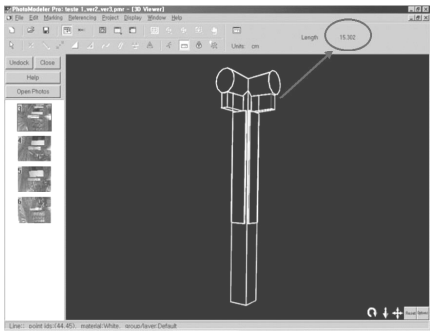

Figure 2. 3D modeling and measurement

A 3D model is a set of connected 3D points, edges, curves and cylinders which represent an object. Three dimensional points have coordinate values for each of the Cartesian axes(X, Y, and Z). PhotoModeler generates 3D

models for visualization and view studies. 3D model can be used to obtain the measurement of each of the component. If the operator knows at least one of the dimension, the tools of scale or control points uses this dimension to extract the real measurement. The dimension of foundation stone or the width of column that we can measure directly can be used as the constraint for scale.

2.3. ACCURACY OF PHOTOMODELER

How reliable is the result from PhotoModeler? No measurement technology can be perfect and all measurement involves performing approximations. PhotoModeler is no different.

First of all PhotoModeler depends heavily on the nature and quality of the photography used for measurement. The quality of photographs is very important to obtain accurate results. However the accuracy of a Measurement Project is dependent not only on the quality of photographs but also on other numerous factors: resolution and position of the camera and digitizer, precise marking, etc.

For example, a project done with the highest resolution Kodak DCS under reasonable user care, PhotoModeler has shown a relative accuracy in linear dimensions of around one in two thousand (1:2,000) for man made objects (with 95 % probability). With higher resolution medium format metric digital cameras shows an accuracy as high as 1: 10,0000. Lower resolution cameras and imprecise marking can reduce the accuracy to one in five hundred (1: 500) or even lower.

2.4. THE ROLE OF PHOTOGRAMMETRY IN ARCHITECTURE

Photomodeler is a modeling and measuring tool based on photogrammetry which is the science of extracting measurements from photographs. This high tech program can be used to measure the dimension of real buildings or buildings only existing in photographs. Therefore this photogrammetric program is useful also for restoration or documentation.

This research uses this photogrammetric program as a tool to clarify the design rule inherent in the tradition Korean architecture. More specifically, the following 2 types of ratio of this building are obtained from the dimension information collected by using PhotoModeler: layout ratio and component ratio.

3. 3D parametric model of Korean traditional wooden structure

3.1. PARAMETRIC RULE OF KOREAN TRADITIONAL WOODEN STRUCTURE

Korean traditional building is an assembly of wooden components. These wooden components are, by their shape similarities and common structural roles, classified into several categories each of which has it's own prototype. For example, circular column is a column prototype from which various different column instances are derived. The dimensions of a component are constrained by ratios. For example, a ratio exists between the diameter and the height of a column. One component may have several ratios among their different dimensions such as column diameter and height as well as mortise width and depth of column head.

Moreover, the assembly of wooden components is systematized like Lego. In other words, there exists a fixed rule in the connection between joining components, and a ratio of one component is related to that of another component in a sequential manner. Thus, the change of one component's dimension results in that of joining component's dimension. Reciprocally, the unknown dimension of a component may be derived from the given dimension of joining component when the interrelated dimensional ratios of joining components are known. The ratio between components also exist, for example, the width of column and the width of top-tie. As Korean traditional wooden structure is canonical in its form and assembly, dimensional ratios of wooden components are densely regulated.

Once 3D digital model of a Korean traditional wooden structure is constructed in terms of parametric modeling technique, we may determine component ratios and the dimensional change of one component may result in that of other components. The new development of photogrammetry measuring technology like PhotoModeler program makes it possible to collect the required information about component ratios from the photos of Korean traditional wooden structure.

However component ratios depends on house type as wells as building scale. As above-mentioned, column, column top-tie, purlin, and beam are the principal components in Korean traditional mansion type structure. The ratios of those principal components and interrelated connection between those ratios are the basic information, which has to be derived from the result of PhotoModeler program.

3.2. IMPORTING DIMENSIONS TO CAD SYSTEM

3.2.1. Component list and dimensions

All most dimensions are measured in Photomodeler. 3D model of UnHyun Palace is built by applying these dimensions to prototypes of components and applying location constraints to them. Its one bay is chosen to test this task sequence. The component list has a column, a top-tie, a purlin, a beam, a strut, a rafter. The detail attributes and imported dimension of these components are listed in Table 1.

TABLE 1.Ccompoenet List and Imported Dimensions

part	Shape Type	attribute	Dimension (unit : mm)
Column	in, out	widthTop	215
		widthBottom	230
		height	3120, 2670
Toptie	.	width	75
		depth	242
		length	2470
Purlin		radius	127.5
		length	2470
Beam	center, up, out	width	335, 176, 180
		depth	400, 394 ,300
		length	3696, 4325.5, 1546.6
Strut		width	896
		depth	95
		hight	970
Rafter	Short, long	radius	120
		length	2400, 3050

With the dimensions of parts, we need also the offset dimensions of columns and rafters, which are listed in table 2. Among them, the ColumnOffset :X is measured directly and it acts as standard dimension finding other dimensions according to ratio in Photomodeler.

TABLE 2. Offset Dimensions.

offset	direction	attribute	dimension
ColumnOffset	X	[0]-[1]	2470
	Y	[0]-[1]	1546.6
		[1]-[2]	3696
		[2]-[3]	1546.6
RafterOffset	X	.	240

3.2.2. Constraints

There exist two types of constraints in a building; location constraints and dimension constraints. We must decide where each components is located referring to the photographs. Location constraints can be different in each building.

TABLE 3. Location Constraints

Part	Location type	Location				
		spot	Linear			
			start	end	mid	direction
Column	in	On y[1], y[2]	.	.	.	.
	out	On y[0], y[3]	.	.	.	.
Strut	.	On Beam-center:center	.	.	.	.
Toptie	y[0] ~ [3]	.	On Column[n],	On Column [n+1]	.	x
	center	.	At 2/3 Strut[n]	At 2/3 Strut [n+1]	.	x
Purlin	y[0] ~ [3], center	.	On Toptie:start	On Toptie:end	.	x
Beam	out	.	On Column[n]-out	On Column[n+1]-in	.	y
	center	.	At Bean[n]-out:end	At Bean[n+1]-out:end	.	y
	up	.	On Column[n]-in	On Column[n+1]-in	.	y
rafter	short	.	On purlin-center	On purlin-y[1], On purlin-y[2]	.	y
	long	.	On purlin-y[1],y[2]	.	On purlin-y[0], On purlin-y[3]	y

* location type is same with shape type in case of column, beam and rafter
* [n]-[n+1] means nth bay of building plan.
* (-) type, (:) attribute

According to this table, we can define dimensional constraints.

Beam-center, up : length = ColumnOffset : Y (1)

Purlin : length = ColumnOffset : X (2)

Beam-out : length = (ColumnOffset : Y : [0]-[1]) + extrusion length of it (3)

3.2.3. 3D model of UnHyun Palace

Figure 3 shows the 3D model of UnHyun Palace obtained by the above mentioned process.

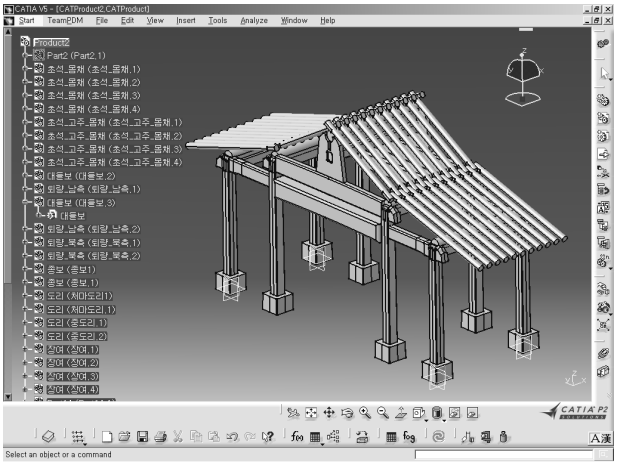

Figure 3. 3D model of UnHyun Palace in CATIA

3.2.4. Finding Dimensional Ratios

It can be classified two major types. First one is layout ratio of wooden structure: bay width of x direction vs. y direction, bay width of x direction vs. building height. Second is component ratio: Internal ratio is among dimensions of one component, and the external ratio between connected components. (Table 4)

TABLE 4. Result Values of Ratios

Ratio type		Param1	Param2	Ratio
Layout ratio		ColumnOffset : Y:[0]-[1]	ColumnOffset : X:[0]-[1]	0.626
		ColumnOffset : Y:[1]-[2]	ColumnOffset : X:[0]-[1]	1.496
		Purlin-center : location :z	ColumnOffset : X:[0]-[1]	1.672
		Column-out : height	Purlin-center : location :z	0.646
Component ratio	internal	Column-out : widthBottom	Column-out : height	0.086
		Column-out : widthTop	Column-out : widthBottom	0.93
		Toptie : width	Toptie : height	0.3
		Beam-center : width	Beam-center : depth	0.837
	external	Top-tie : width	Column-out : widthTop	0.349
		Purlin : radius	Top-tie : width	1.7
		Rafter : radius	Purlin : radius	0.94
		Beam-out : width	Column-out : widthTop	0.837
		Beam-center : width	Beam-out : width	1.86
		Beam-up : width	Beam-center : width	0.525

* purlin-center: location :z = The height of structure

The ratios in Table 4 are calculated by multiplication only. Although this

method is simple but it is clearer.

4. Conclusion

Photomodeler - a photogrammetric program - is used as a tool to measure the dimension of building. Application of this program to Korean traditional building – UnHyun Palace – gives the information for the 3D parametric modeling and make clarify the design rule inherent in the tradition Korean architecture like 2 types of ratios: ratios among the parts of a component, ratios between components and layout ratios. These ratios can be used to analyze the variation of each building components with the component prototypes.

Acknowledgements

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