8th International Quality Conference
May 23rd 2014
Center for Quality, Faculty of Engineering, University of Kragujevac

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DEFORMATION MEASUREMENT OF FURNITURE BUILT USING PLYWOOD PANELS

Abstract: *Wood-based panels, first of all plywood, are widely used in contemporary furniture manufacturing. In this paper, methodology for deformation measurement of plywood furniture is presented. The concept is demonstrated on deformation measurement of book case loaded with books and/or uneven floor. Results show that the method is simple to implement, allows for measurement of deformations of large pieces of furniture and provides a global picture of the behavior of observed objects exposed to the loads.*
Keywords: *Photogrammetry, Measurement, Furniture, Plywood panels, Deformation*

1. INTRODUCTION

Nowadays furnitures are mostly produced using wood-based panels [1]. Among these materials, plywood is widely used in contemporary furniture manufacturing. Due to many of qualities, plywood provides great opportunities both for designers and manufacturers. With 2D templating technology, furniture assembly is revolutionized, allowing production to take place on demand.

Computer aided manufacturing (CAM) and measurement technology has caused a general quality furniture improvement, as advanced inspection of assembled pieces discovers even minute faults [2]. Computer aided measurement technology has made furniture fabrication a countertop industry. Software and virtual models simplify furniture design, which has moved from the studio to the virtual world [1]. On the other hand, reverse engineering provides the data for exact replica of free-shape furniture.

Elastic deformations are present in many objects in our everyday life [3, 4]. When design elastic deformable objects, such as plywood furniture, either in computer animation or in the real world, engineers' task is to ensure the objects behave in a desired and stable way. Researching deformation behavior, studing strength characteristics, considering impact of the wenner quality would contribute to effective utilization of plywood [3]. Analysis of panels deformation is especially important when it is necessary to achieve a particular behavior of materials under the influence of load (dead mass, clothes, books,…) [5, 6].

3D measuring technology, like the portable arms, laser and 3D sterevision scanners delivers furniture measurement data with high accuracy to a CNC machine that cuts wooden furniture parts to exact specification [2]. With accurate cuts by CNC machines, furniture manufacturers ensure that furniture fits exactly to plan.

The deformation measurement software, such as CMM2Deformation or TRITOP Deformation are ideal to carry out high-precision deformation measurement of uneven and complex surfaces which is not be possible with tactile measurement devices [7, 8, 9]. In this paper, methodology for measurement of plywood furniture deformation is presented. The workflow is demonstrated on deformation measurement of book case loaded with books and/or uneven floor.

This paper is organized in the following way: in Section 2 the deformation measurement algorithm is given, in Section 3 case study examining deformations of bookcase are presented. Final remarks and conclusions are presented in Section 4.

2. DEFORMATION MEASUREMENT ALGORITHM

2.1 General steps

General steps to carry out a deformation measurement of wood-based panels are as folows: (a) Preparing the measuring object, (b) Photogrametric recording of each individual deformation stage, (c) Creating a new deformation project, (d) Choosing the component for stage transformation and stages' identification, (e) Determining coordinate system (if required), and (f) Displacement field generation and analyses.

The reference points are applied to plane or just slightly curved surfaces and are visible in all cammera postions [8, 9]. The markers are further away from each other than the expected deformation (at least double spacing). This ensures correct automatic renumbering through all stages later. In addition, these markers should not be applied in an exact horizontal line so that they can be identified correctly later. Well distributed the uncoded reference points in regular distances all over the object gives an overview of the general deformation.

2.2 Measurements of individual load stages

After the measuring object has been prepared for the deformation measurement, the required images are recorded using a photogrammetric camera. Digital images are recorded from various views, with each image set representing one state of the object. This means that each image set represents an individual, socalled deformation stage and is a self-contained project. As the measuring principle here as well works with reference point markers applied to the object, the system automatically calculates the 3D coordinates of these image points and compares their position in the different stages with each other.

Then, the measuring object is exposed to a deformation situation, e.g. it is load by clothes, books, ... The object thus modified again is recorded photogrammetrically and this procedure needs to be repeated until all desired states of the object are captured. The deformation system reads these images as stages into a new deformation project and calculates the 3D coordinates of the reference points and thus their position. They are displayed in the 3D view as a point cloud.

3. CASE STUDY: BOOK CASE

3.1 Model description

The aim of the study was to verify deformations of book-case built using symmetrically veneered panels linked using industrial glues. To realise the aim designing and building of book-case from strach for analysis of deflections of furniture panels was done.

Bookcase has dimensions of 2500x1000x300mm (Figure 1). It is made of 18 mm thick plywood panels (Figure 2). Model loading was done by placing books, while deformation measurement was performed at partial and full load (Figure 2). Reference objects are placed on the frontal surfaces to determine the deformation of the model in one plane [8, 9].

Prefabricated coded reference points, necessary for the reconstruction of 3D scenes, are coated with a layer of magnetic and are intended for the measurement of ferromagnetic materials. However, their use with other materials is hampered. Consequently, so-called user-defined reference points were used. Their main characteristic is that the user makes it himself useing technique that best suits the needs of measurement. Applied reference points are printed on adhesive paper using office printer. The use of these reference objects does not affect the accuracy of measurements [10]. Uncoded reference points of diameter 5 mm are set at approximately 50 mm. The model is composed of 436 points.

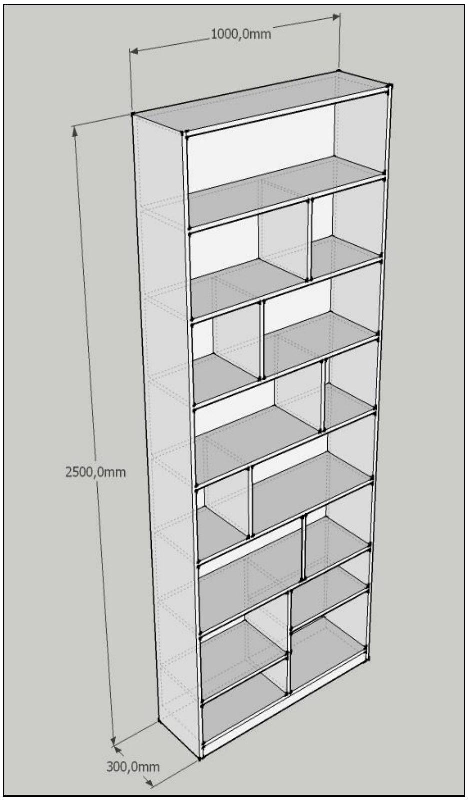
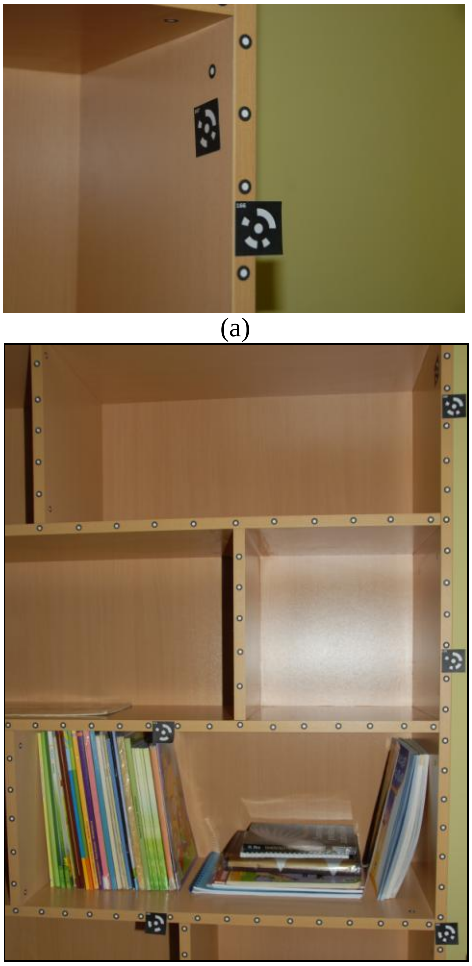


Figure 1 - Sketch of book-case

Static points are placed in positions with no or just insignificant deformations (relative deformation/relative movement, compensation of rigid body movements) are expected/occurred (Figure 3).



(a)

(b)

Figure 2 - Measuring object:
(a) Application of refence object (coded and uncoded reference points) and
(b) Partially loaded model

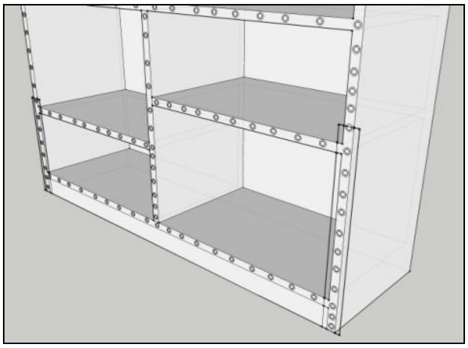


Figure 3 - Static points

3.2 Results

In order to assess the deformation of the object, all stages are aligned to the reference stage based on components and fixed points which have to be specified [8, 11]. During the following identification, the IDs of the uncoded reference points which the system randomly assigns will be renumbered automatically so that the same points in all stages will have the same ID. A displacement field, defined by selecting an area of points, is the area for which the software will display the computed deformation through all stages.

The deformation is calculated automatically as soon as the stage is identified. Within the displacement field, the 3D view displays in color the deviation of the points from the stage selected as deformation reference. Measurements and further analyses may be carried out. Finally, a report is created which may be exported for further use.

Based on measurements performed by photogrammetric method, we analyzed the following aspects: (a) Deformation of structural components due to static loading (weight of books), and (b) The impact of the floor on the behavior of loaded furniture. In both analyzes two loading cases are considered: (a) Specimen is partially loaded, and (b) Specimen is fully loaded.

Deformations of plywood components are determined using module TRITOP Deformation. The object's deformations are displayed as colored point deviations. Partially loaded model deformation caused by impact of evenness of the floor is shown in Figure 4. Fully loaded model deformation caused by impact of evenness of the floor is shown in Figure 5. Partially and fully loaded model deformations in frontal (X) and lateral (Y) direction due to impact of evenness of the floor are shown in Figures 6 and 7. Shelves deformation caused by partial and full loading are shown in Figures 8 and 9.

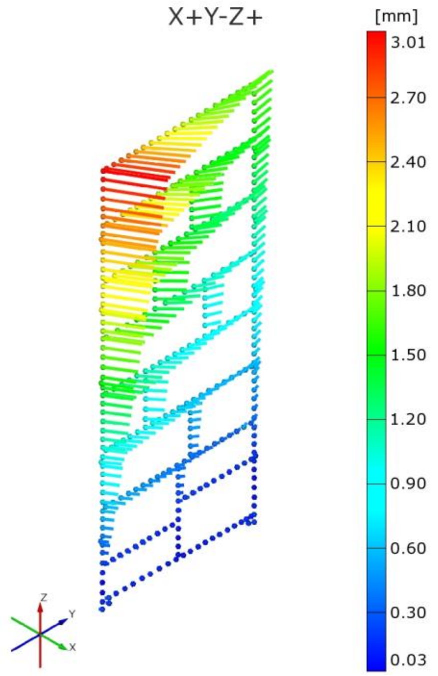


Figure 4 - Partially loaded model deformation due to impact of evenness of the floor

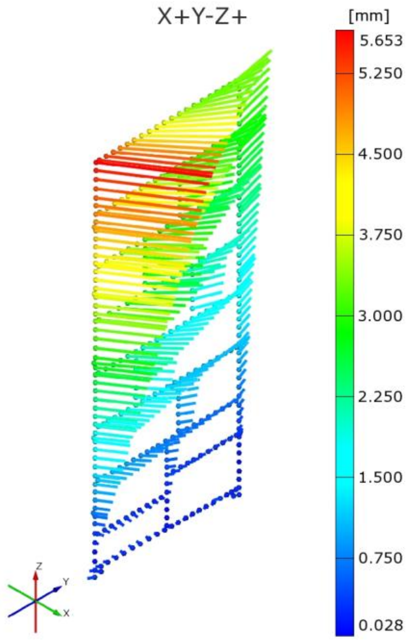


Figure 5 - Fully loaded model deformation due to impact of evenness of the floor

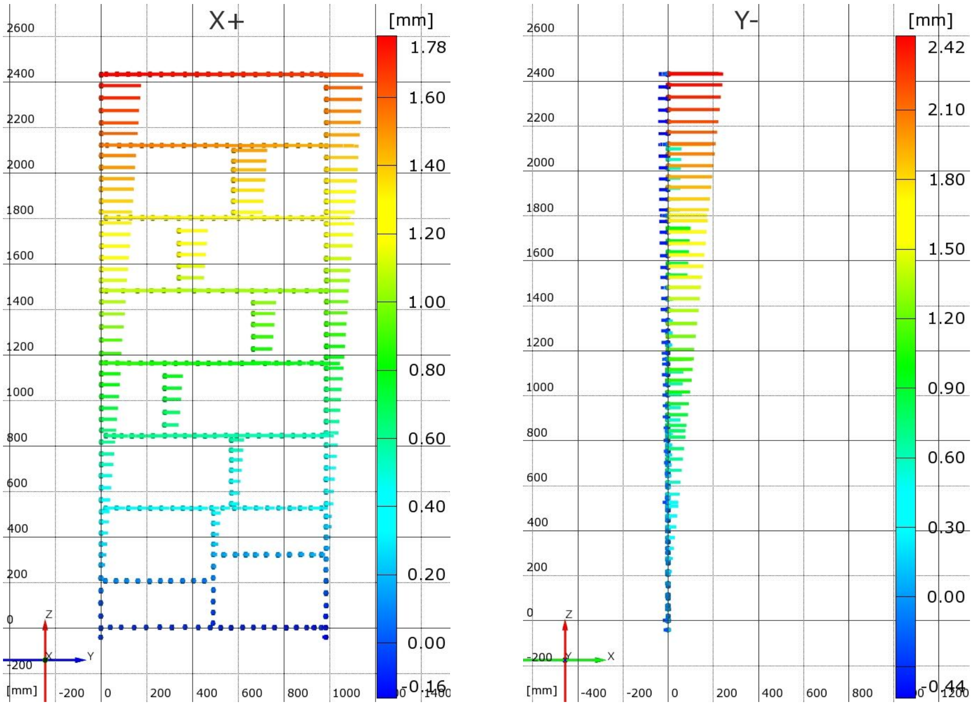


Figure 6 - Partially loaded model deformation in X and Y direction due to impact of evenness of the floor

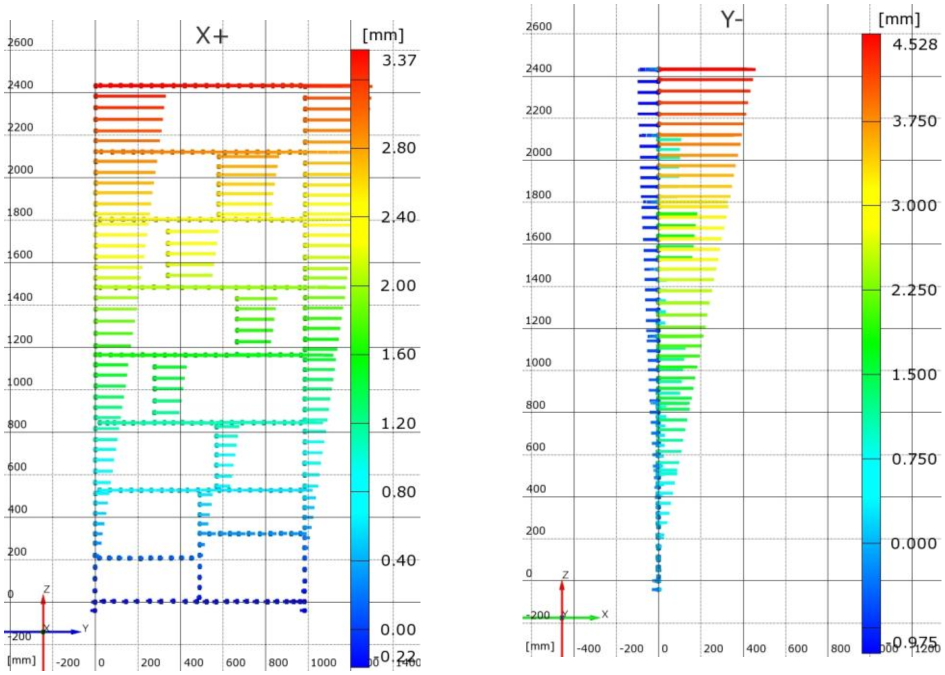


Figure 7 - Fully loaded model deformation in X and Y direction due to impact of evenness of the floor

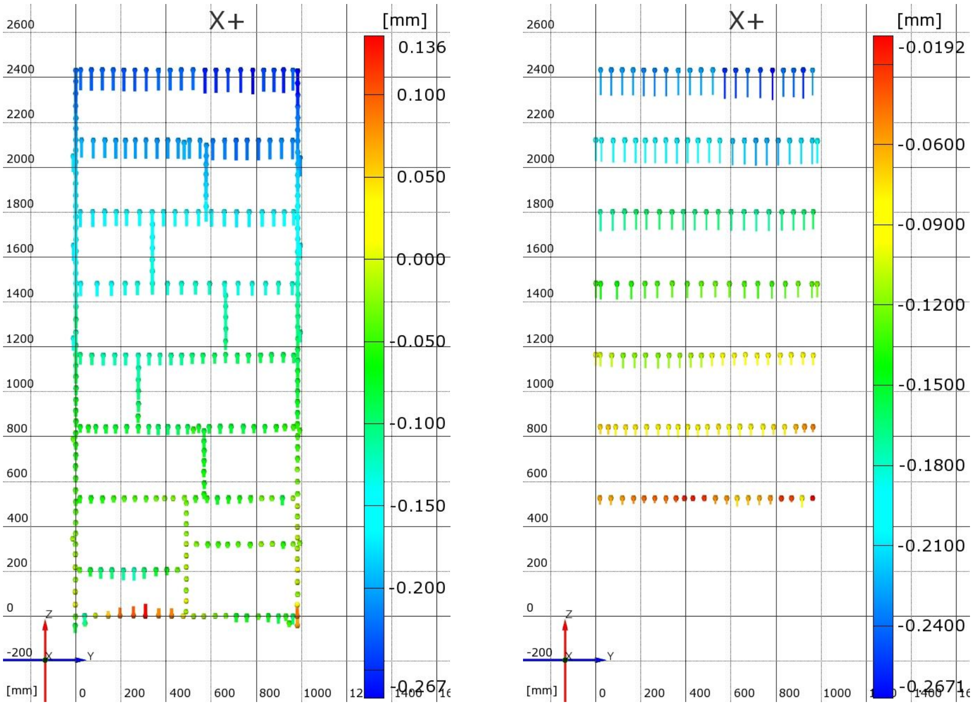


Figure 8 - Shelves deformation due to static loading (partially loaded model)

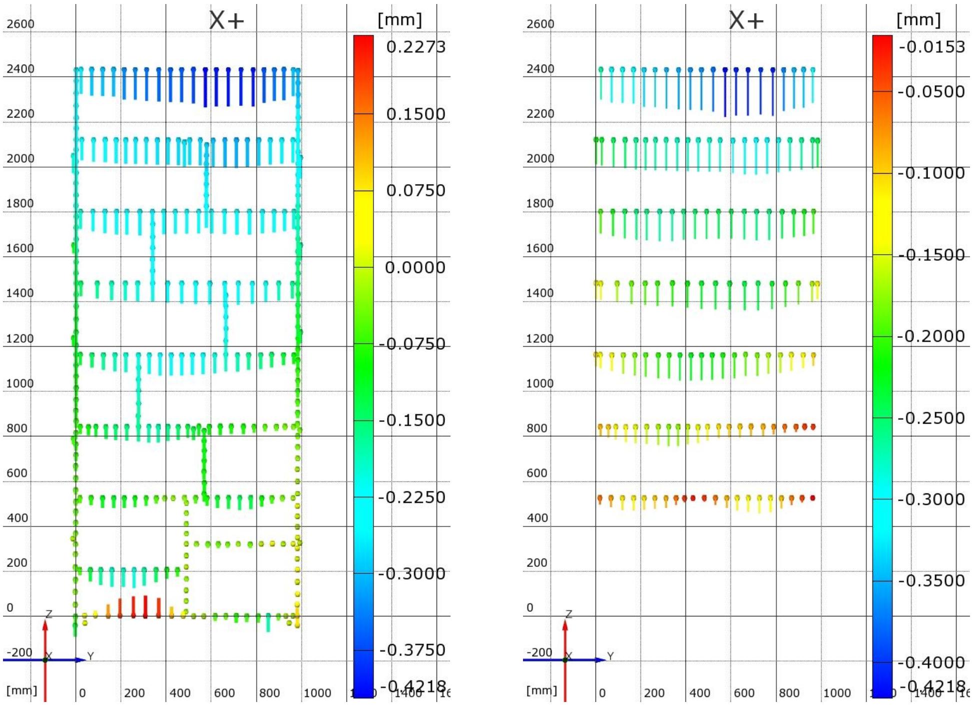


Figure 9 - Shelves deformation due to static loading (fully loaded model)

4. CONCLUSION

The result from this study aimed at determining the deformation characteristics of furniture built using plywood panels. Results show that the method is simple to implement, allows for measurement of deformations of large pieces of furniture, and provides a global picture of the behavior of observed objects exposed to the loads. This method allows the assessment of quality furniture in the exploitation and other conditions (packaging, transport, earthquake,…).

As the introduction of technologies which fully use natural and derived wood resources with all its structural deficiencies is a priority since the deficit of high quality wood materials is becoming increasingly evident, the results can be used for strength design of the joints or the furniture constructions manufactured from plywood in order to optimize their sections or improving their strength.

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Acknowledgment: Research presented in this paper was supported by Ministry of Science and Technological Development of Republic of Serbia, Grant TR 32036.