GRASP - A Prototype Interactive ***GRA***phic ***S***awing ***P***rogram[1]

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Abstract

A versatile microcomputer-based interactive graphics sawing program has been developed as a tool for modelling various hardwood processes, from bucking and topping to log sawing, lumber edging, secondary processing, even veneering. The microcomputer platform makes the tool affordable and accessible. A solid modelling basis provides the tool with a sound geometrical and topological foundation. The current features, capabilities, and future implications of the tool prototype are described in this paper.

Background

In the area of production operations, computer simulation has proven to be a versatile analytical supplement to physical testing. In lumber production, computer simulation is of special interest because it enables the repeated sawing of a log sample, in essence a means for examining the effects of several log breakdown patterns and sawmill variables. There have been previous simulation studies on hardwood log breakdown in particular (4,6,9). This type of simulation is of a physical nature that involves geometric representation, in contrast to systems simulation studies (2) that observe the operation of a system over time.

In the late 1970's Pnevmaticos et al. introduced the first graphic simulation of log sawing using a hybrid graphics terminal (5). Graphic simulation has the advantage of a visual feedback on spatial relations vital to hardwood processing. Pnevmaticos used truncated cones and cylinders to approximate the log shape, and rectangular boxes to approximate defects. The intersection of the log with the saw was treated as a linear programming problem.

In 1988, Occeña and Tanchoco (3) reported the development of a graphic log sawing simulator as an analytical tool for automated hardwood log breakdown, representing the log and its defects as nonregular polyhedra and the simulated sawing as a Boolean operation between closed solids, The polyhedral model more closely approximated the true shape of the log and its defects than previous log/defect graphics models. It was implemented on a minicomputer platform using device-independent graphics and user-developed programs.

A subsequent paper by Todoroki (8) reported the development of an automated sawing simulation program directed towards the same of end of evaluating sawing strategies. Logs were represented as a series of polygon cross-sections and defects as cross-sectional whorls. The use of non-solid models emphasized speed over precision and flexibility in the representation of the log and defects.

The continued interest in developing operation simulators attests to the significance of such modelling tools. Concurrently, researchers have been pursuing studies on non-invasive internal defect detection (1,7,10) with the intent of developing the capability to “see” internal defects inside the log. This capability will lead to improved hardwood log breakdown decision making that will yield higher grade lumber. A logical consequence of the capability to “see” inside a log prior to sawing is the need to resolve the issue of how such information can best be used to arrive at a higher yield. Given the importance of a realistic representation of the log and its internal defects, and the usefulness of a tool that will enable repeated interactive sawing of the same log sample, an interactive graphics sawing program for wood processing that runs on a microcomputer has been developed.

This paper describes a prototype microcomputer-based interactive graphics sawing program for wood processing that integrates graphics rendering, solid modelling, and data representation. An earlier version of a program founded on the same modelling principles only ran on a much larger computer (minicomputer platform) and did not have a tightly integrated environment (3). This graphics sawing program, which we call ***GRASP*** (for ***GRA***phic ***S***awing ***P***rogram) is unique in its flexibility to model just about any sawing operation, from bucking, topping, log breakdown quartering, veneering, to edging, trimming, secondary processing, even extracting and representing furniture components. It is founded on solid modelling principles, which endows it with a robust foundation in geometry and topology. The implementation on a microcomputer platform makes it an affordable and accessible tool for many users.

Data reconstruction

The input data for ***GRASP*** can be an object from any stage of the wood processing, e.g., timber, log, quarter-log, flitch, board, blanks, etc. They have to be represented as closed polyhedral solids, i.e., a set of concatenated polygonal patches or faces that fully envelope a region describing the object. In this current development, we focused on logs. The sample data consisted of 12 foot red oak logs from the USDA Southeastern Forest Experiment

Station. The data came in the form of digitized coordinates representing the cross-sectional profiles of the log and its internal defects. These profiles were sampled at 2 inch intervals along the length of the log. For this raw data to be useable by ***GRASP,*** solid representations of the log and the defects had to be reconstructed from the cross-sectional profiles. ***GRASP*** itself was used as a tool for reconstruction, uniting the profiles into polyhedral solids. To reduce the magnitude of the resulting data files, the profiles that did not exhibit significant variation from their adjacent profiles were excluded from the reconstruction. This data reduction procedure maintained the integrity of the solid representation. Figures 1 and 2 illustrate a reconstructed log and defect, respectively. Note the irregular intervals of log cross-sectional polygons as a result of the data reduction.

GRASP prototype

Features

The prototype interactive graphic sawing program was implemented on an IBM-compatible microcomputer. The minimum hardware configuration is a 386 CPU with a math coprocessor, 4 Mb of RAM, and VGA graphics adapter, which is considered to be lightweight by today’s standards. Microcomputers today come with much more power than these minimum requirements. GRASP runs on DOS, as well as within Windows and 0S/2 on a DOS emulation. The sawing program uses a solid modeller as the core engine for the sawing simulation of the log and defect solids. The basic principles of solid model representation and processing were described earlier in (3).

The integrated graphics can render the objects simply as see-through wire-frame images (as is common in computer-aided design or CAD), as solids with obstructed polygons hidden from view (using hidden line removal), or as realistic-looking shaded objects. Figure 3 shows the log as a wire-frame image with some of its knot defects. Hiding polygons that are normally hidden from view, as in Figure 1, provides the capability to show or hide internal defects as desired.

There are various other features in GRASP that are common in graphics-oriented programs, such as multiple views (front, top, orthographic, etc.), windowing (splitting the screen into several windows, each with a different view), magnification or reduction scaling of the image (zoom in/out), and calculation of dimensions (length, width, area, volume, etc.). Figure 4 illustrates a magnified view of a section of the wire-frame image, giving a closer look at the internal knot defects.

Processing Capabilities

GRASP is a versatile tool that can be used to interactively and graphically saw solid representations of wood objects in various stages of the process. It can be used for bucking and topping the felled timber, for log breakdown into flitches, for edging and trimming of flitches into lumber, for ripping and cross-cutting finished lumber into furniture blanks.

The resulting objects of a sawing operation are solid objects themselves. This property allows the same kerf-removal process to continue on resulting objects, akin to the downstream secondary and finishing processes. Figure 5 illustrates a quartered log such as would be done for a veneer processing. Figure 6 illustrates a live-sawn log as an example of a log breakdown pattern that can be nondestructively repeated on the same log at different opening faces. Figure 7 illustrates aboard that has been ripped and then cross-cut to extract clear-faced blanks as furniture components.

Study implications

GRASP has many potential uses in wood processing work. It can be used as an analytical tool for research to nondestructively examine different ways of converting raw wood material such as logs into lumber, veneer, furniture blanks, etc. For this purpose, it is also a vertically integrated research tool. It can be used for the various stages of physical and mechanical transformation of wood, from primary processing, through secondary processing, to finished product manufacturing. It has an open architecture which will allow the model to be embellished, or adapted for other functions. It can also be used for training purposes, providing a flexible, programmable, and nondestructive environment for tailoring training for a variety of solid wood processes.

Summary

This paper described the features, capabilities, and implications of the prototype for a microcomputer-based interactive graphics sawing program for wood processing called GRASP. It is a versatile program that can handle most solid wood conversion processes, from bucking and topping, to primary and secondary processing, and even manufacturing of furniture components. The program has an open architecture and can be extended for a variety of purposes. We are currently extending it to provide access to lumber grading programs. We are also studying means of automating the generation of saw controller code from sawing instructions, and automating the execution of sawing instructions in a batch mode. Some potential uses of GRASP include research into better ways of improving forest product yield, and training in a flexible and nondestructive environment.

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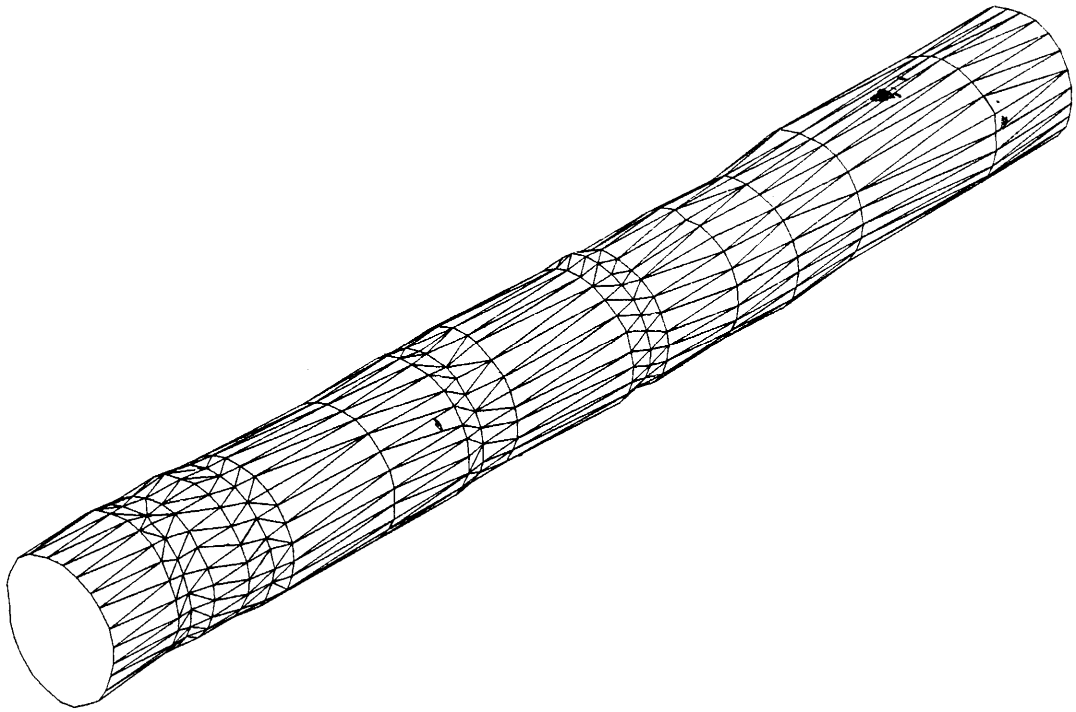

Figure 1. Reconstructed log.

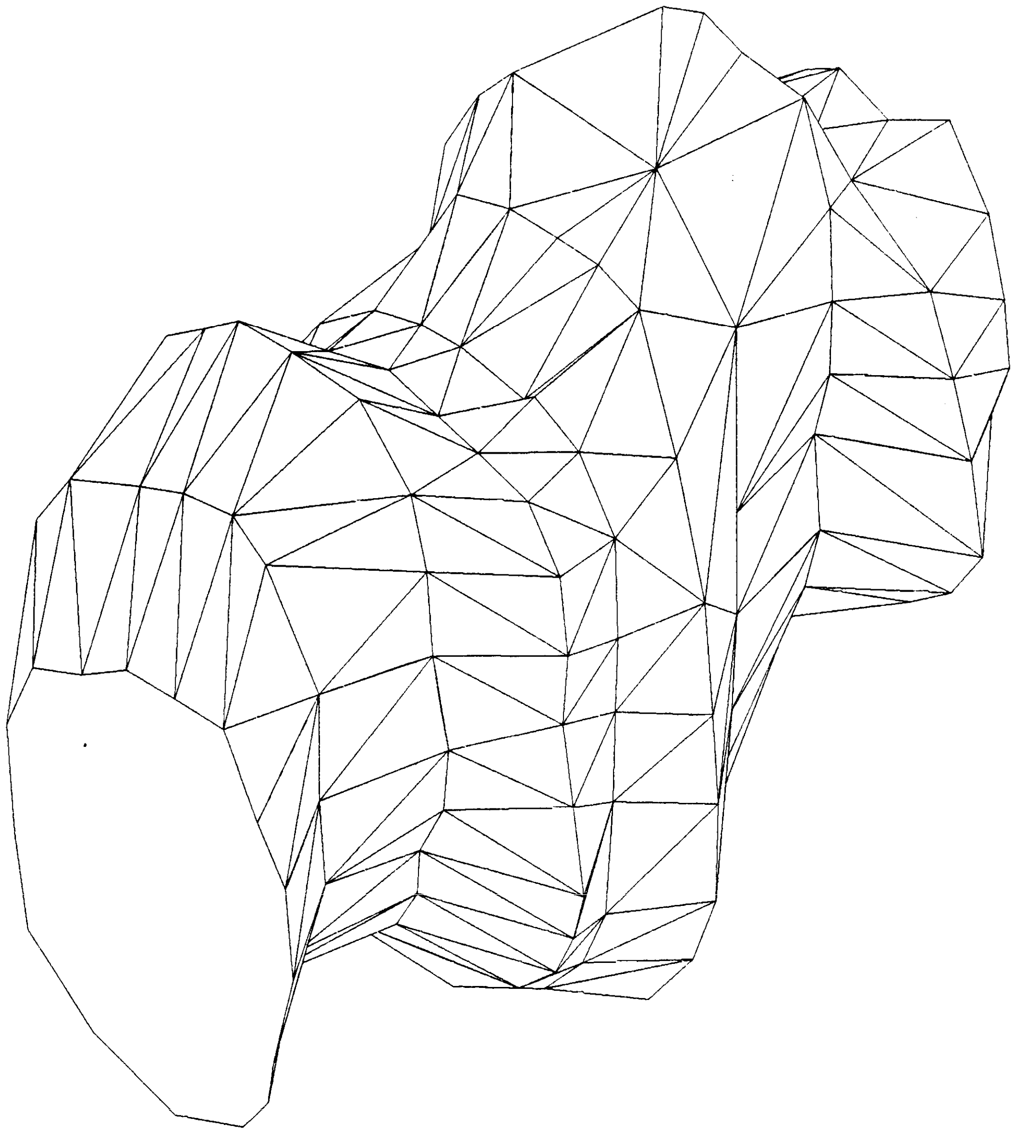

Figure 2. Reconstructed knot defect.

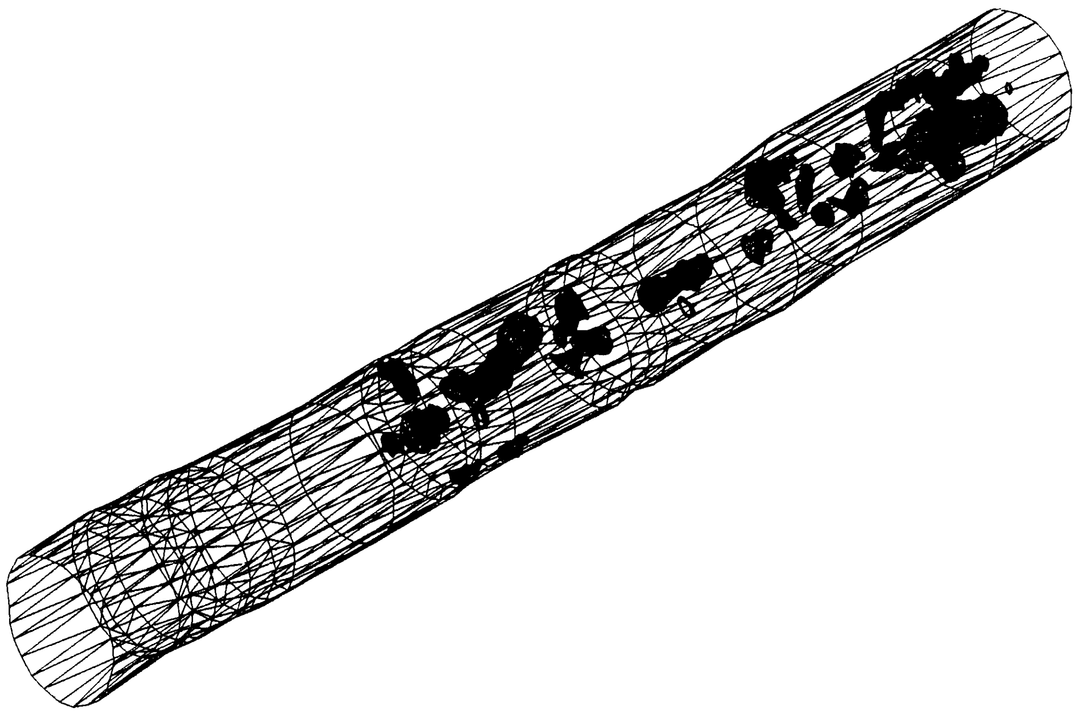

Figure 3. Wire frame rendering with internal knot defects revealed.

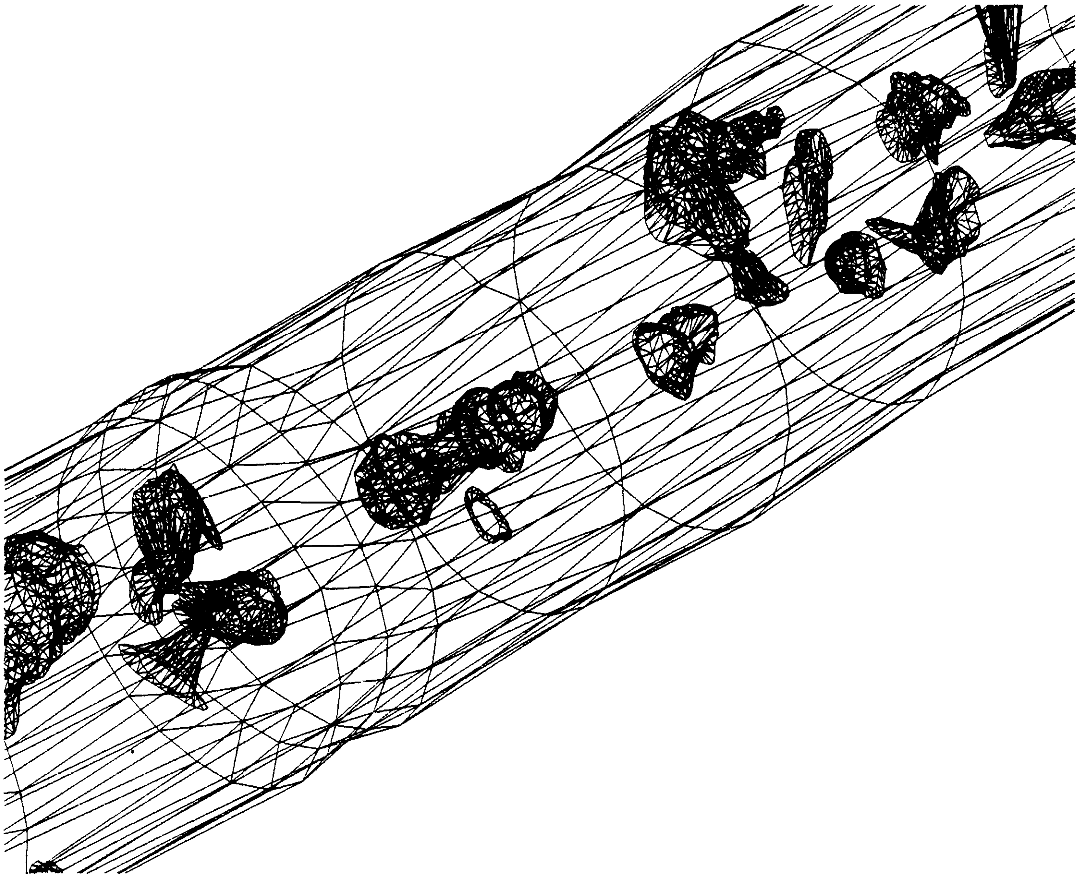

Figure 4. Zoomed-in view of a section of the wire-frame image.

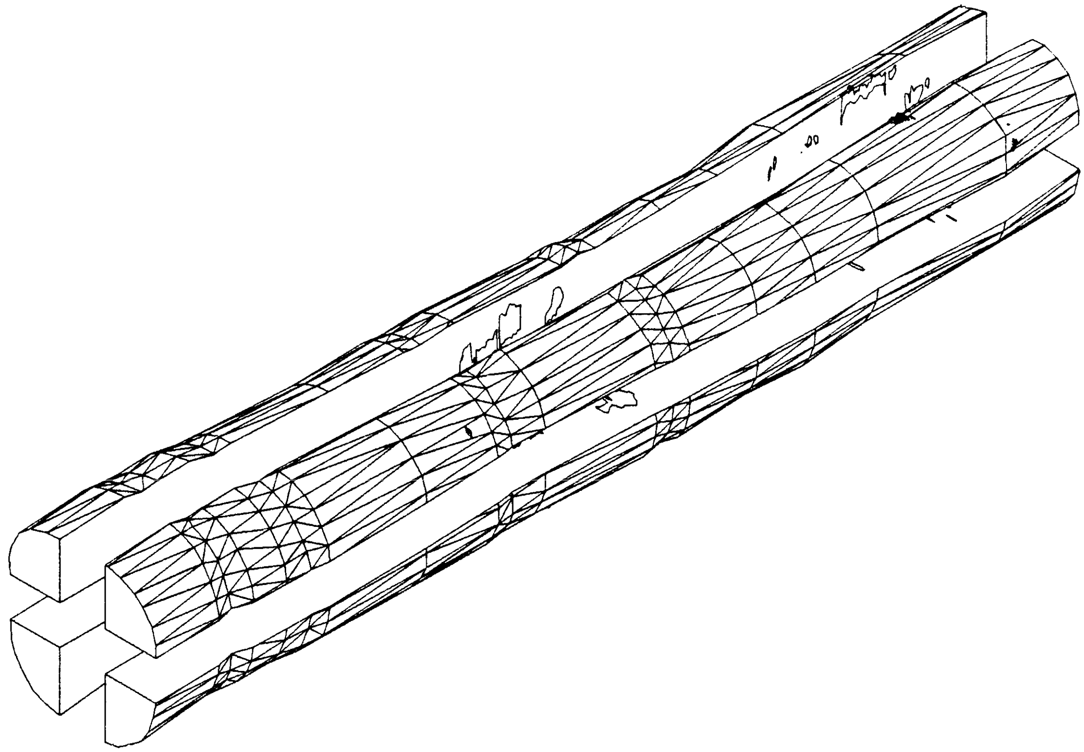

Figure 5. Quarter-sawn log for veneering process.

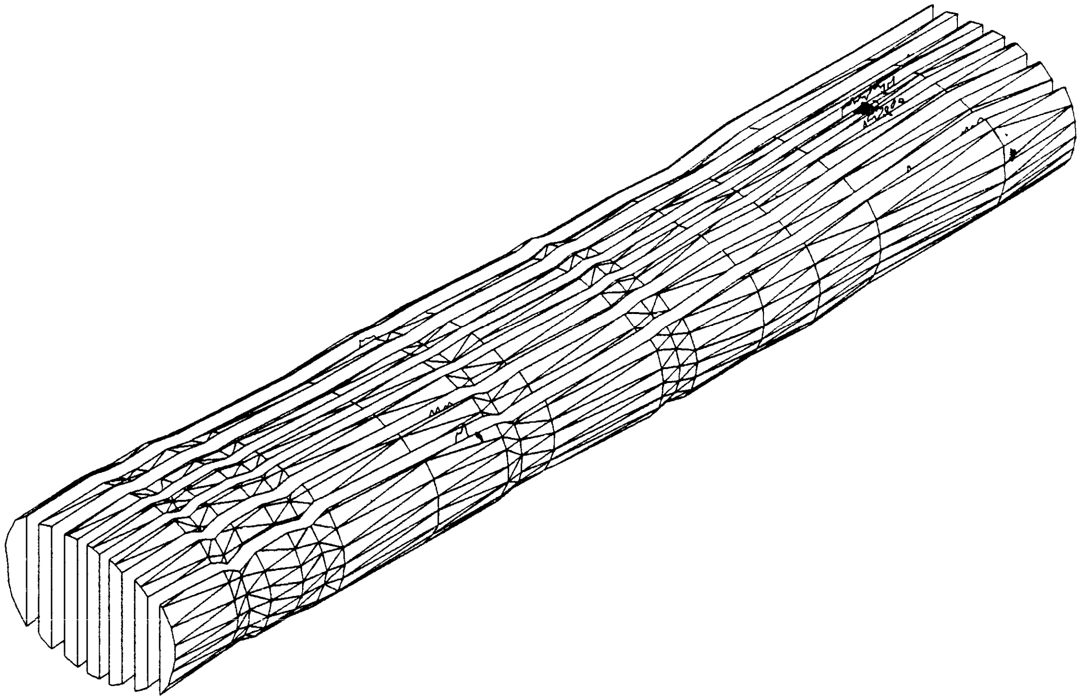

Figure 6. Live-sawn log.

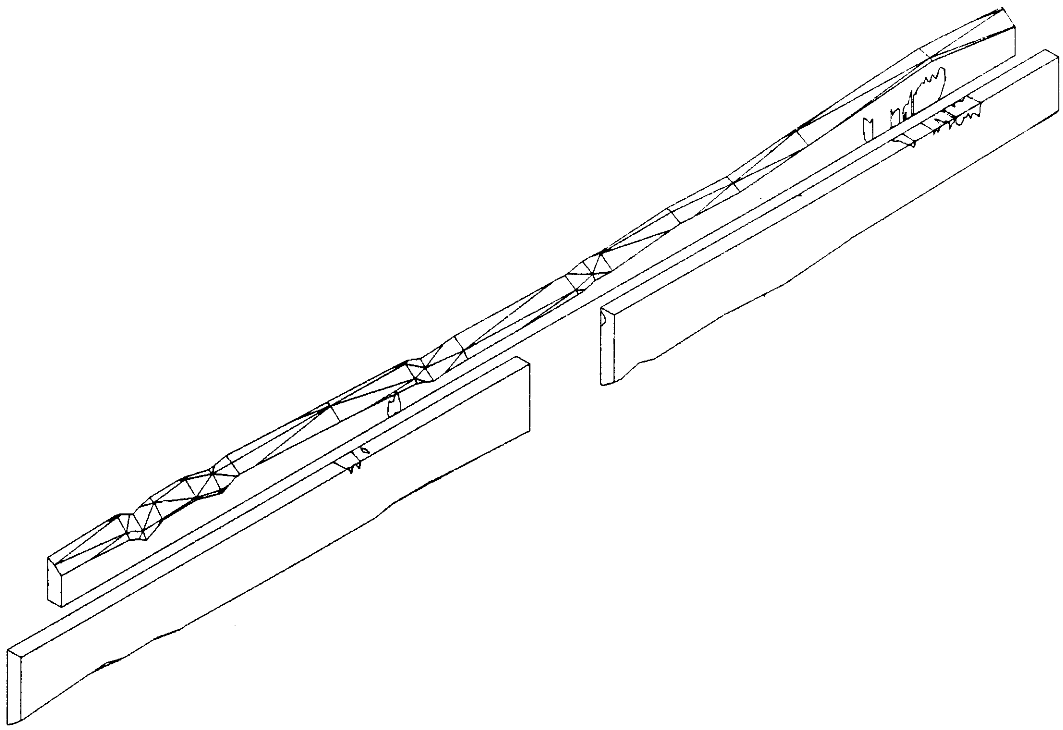

Figure 7. Cross-cutting and ripping of flitch.