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Non destructive Control tool for wood traceability

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Abstract

The concept of traceability is defined according to the standard ISO 8402 like “the ability for the retrieval of the history and use or location of an article or an activity through a registered identification”. Their implementation in the wood industry is delayed because of the limits of classical automatic identification systems in regard to the nature of wood and the features of the manufacturing processes.

This paper presents a new solution for the wood products identification. This is a biometrics approach through the use of a non-destructive technique. With this approach, the assumption is made that each product is unique with unique measurable characteristics. The microwaves sensor used to acquire the intrinsic signature of a piece is presented as well as the methodology for the identification.

Keywords: wood product, automatic identification, traceability, k-nearest neighbor

1. Introduction

The complete follow-up of products from its origin to its final use has been strongly developed lately, especially in food and automotive industries. The capacity to perform a complete follow-up of products in industries has been possible with the implementation of systems of automatic identification, which are able to establish a link among the product, the database of the product and of process. This follow-up process is currently named “traceability” and many technical
solutions have been developed to carry it out, e.g. sticky labels and bar codes that allow a good identification of products and their traceability. However, according to the type of manufacturing process and products these techniques induce the utilization of high quantities of “consumables”, thus increasing costs.

In the case of wood industries, the implementation of ordinary identification systems used in other industries presents implantation problems, mainly due to the extremely variable nature of the material and the particular features of the manufacturing process. Currently, identification systems as the code bars and marking techniques are used for the follow-up of wood products. The whole of the techniques suitable for wood follow-up is listed by [Drykstra 2002]. It appears that it concerns only wood products from the forests to the input of the sawmills. Indeed, during the next processes (figure 1), effects due to: the loss of raw material in the cutting or planing steps, the diversity of products, the divergent character at the beginning and convergent at the end of the process, the usual loss of the FIFO order (First In First Out), and the high implementation cost, have led to slow down implementation of the fore-mentioned techniques.

However, if follow-up of products were assured, it would be possible:

- to control and differ finished products elaborated with raw material coming from sustainable managed forest. This situation was the first indication of the necessity for developing and implementing systems of products follow-up [Stevens 1998].
- to increase the efficiency of the process and its technologies, [Töyrälä 1999] highlights that it is possible to improve the logistics chain, the management, the supply and the optimization of raw material.
In order to follow-up products, new solutions have been considered by the use of non-destructive control techniques. We implemented an identification system based on the biometrical technique. This denomination is used as it makes reference to personal identity and it takes into account the biological variability of the materials when making the identification. The similar point of view was developed by [Chiorescu 2003] utilizing of scanner information. Indeed wood is a heterogeneous and anisotropic material, showing a high variability in its structure. Features such as knots, pitch pockets, and cross grain may be found in different degrees in wood [Kollman 1968]. Therefore, the extremely variable nature of wood promotes the existence of unique characteristics, just as the genetic human code. Charpentier and Choffel have shown that these characteristics can be used as a pattern to recognize [Charpentier 2003]. Moreover, some manufacturing processes would not support the addition of equipment on the product as proposed by the other identification systems.

2. Identification system
This paper presents a biometrical technique based on the use of a micro-wave sensor which allows to acquire an intrinsic signature of the wood products. This sensor was first employed in the laboratory for the detection of the features of wood such as knots, cross grain [Charpentier 2003] and also the determination of the mechanical characteristics of timber [Choffel 1992]. The results obtained in this utilization have established the bases of the current work. Indeed, microwaves interact with the material according to its dielectric properties [Torgovnikov 1992]. The propagation of this type of waves through the wood is mainly influenced by the moisture content and the presence of features (knots, cross grain, etc.). The moisture content has to be maintained constant to highlight the other factors. Indeed they are more variable from one board to another, consequently more interesting for the automatic identification.

The sensor is composed of an emitting part (10 GHz frequency, 100 mW power) and 16 aligned receivers. The product circulates between the emitter and receivers, then its signature is digitized to be processed on a computer as shown in figure 2. Two photoelectric cells allow detection of the product. Its length is known by the addition of an encoder. The lengthways resolution of the sampling has been fixed to 5 mm.

The characteristics of the test sample are the following: 81 boards of *Pinus sylvestris* of 25 x 110 x 1500 mm, specific gravity of 0.5 and average moisture content of 9%. A factor affecting the signature is the distance between emitter-wood and receiver-wood. These distances can be modified, for example, in a warped board where there is no stability of the product during measurement, which results in additional features or perturbations with the consequent identification problems. In particular, a part of the data processing presented in the next section is dedicated to this problem.
Figure 2. The microwave system for wood identification

3. Principle of identification

In the domain of pattern recognition, there is a large number of methods [Dubuisson 1990]. Similarities may be found between handwritten signatures and microwaves signatures. Then, the recognition of signatures consists in defining a numerical criterion that specifies the level of resemblance between two signatures inside a space [Dubuisson 1990], [Parker 2002]. This can be considered as a problem of k-nearest neighbor (knn) inside the defined space of characteristics.

In the present case, the algorithm based on the statistical approach using the knn method has been developed. Two types of representation spaces (reference spaces) were analyzed. The first space corresponds to the vector formed by statistical characteristics of the signal. Parameters such as the average, standard deviation, average curvature, maximum and minimum value, signal length are extracted on the signal and compose this vector. The second space is the vector formed
by all the points composing the signal, here each point of the signal represents a particular characteristic. The signatures measured are made up of 310 points, therefore the dimension of the vector is 310. When a product is to be identified it will see its signal positioned and the nearest signal will be located (figure 3).

Figure 3. Reference space for identification

The distance between the unknown signal and the referenced one is computed as the Euclidean distance. It will set the criterion of decision and it will represent the degree of proximity. The equation of the Euclidean distance is given hereafter:

**Euclidean distance**

$$d_{xy} = \left( \sum_{i=1}^{310} (x_i - y_i)M(x_i - y_i) \right)^{1/2} \quad (1)$$

Where:

- $\mathbf{x}$ is the unknown signature of a product and $\mathbf{y}$ the known signature among those of reference.
- $x_i$ and $y_i$ are the i-esime characteristic of the signature $\mathbf{x}$ and $\mathbf{y}$ and $\mathbf{M}$ is the weighing matrix taking into account the variability on the signatures.
In this research we study the effect that takes place if the signal to identify (unknown signal) changes with regard to the reference space. As first stage, the identification problem was focalized into the storage operation. The classic manufacturing processes present FIFO queue of products, but in our case the intermediate stocks are not ensuring that any order of products will be respected. Additionally, it is not guaranteed to measure a product neither in the same face nor orientation. Figure 4 shows the four possibilities for the input of product on the machine and figure 5 presents the associated signatures. We note that the signatures coming from different sides in the same wooden piece are not completely similar, although measurement was made in the same area.

Figure 4. Four possibilities the input of product
The recognition procedure consisted in taking the acquired signals of a side of the wood product as reference and those belonging to the other sides, as the unknown signals to be identified by means of the developed algorithm.

To validate the performance of this algorithm, a criterion to evaluate the identification decision is defined. This is performed using the concept of confusion coefficient (CC). For this, an index of vicinity between the identified signal and the second next to her is calculated, i.e. the ratio of the two smallest values of distance. The CC fluctuates between [0,1]; one have that the nearer to value 1 the more ambiguous the decision will be and consequently with a higher risk.

4. Results and discussion

4.1. Treatment of signals

Treatment of signatures was carried out for increasing the algorithm performance in view of the difficulty found in the identification of signatures. To begin, a first low-pass filter on the signatures allowed to eliminate the inherent measurement of noise due to the conveyor belt motion.

The signatures acquired by the system shows fluctuations at the beginning and end due to changes in air-wood medium when the product enters and goes out of the system, this effect is named “edge effect” (Figure 6). Also, we observed the appearance of a curvature on the signatures in warped products, as the signals measured on each side of the same piece of wood were different. This situation is explained because the process of microwave measurement works by transmission-projection; the effect of turning the piece entails a difference of positioning to
the plane of the conveyor belt system. The general appearance of the signature is then modified because the intensity of the received signal depends on distances produced between emitter-product and product-receiver (Figure 7). This variability of the measurements produces a high probability of error in the decision.

The signal processing for eliminating the edge effect is a simple elimination of these zones. The appearance of curvature on the signatures is eliminated by estimating the general curvature through a polynomial of degree 7, afterwards this general curve is subtracted from the signatures resulting in the straighten signature centered around zero (Figure 8). The polynomial degree has been heuristically selected from the general curvature observations of the signals.

In spite of removing these particular characteristics in the signatures for the identification process that were previously mentioned, we observed a least consistency in the lateral zones compared to central zones. For this reason we decided to ponder the values so as to put the central points forward. The weighing coefficients are introduced by mean of the diagonal matrix $M$ in the equation (1) and (2). The variation of the weighing coefficients varies from 0.5 to 1 according to the position of the points of the signal.

![Figure 6. The signature obtain by means the microwaves system](image)
4.2. Rate of recognition by k-nearest neighbor

The recognition of wood products by the k-nearest neighbor shows a high degree of identification when the signatures are treated. The vector formed by statistical characteristics extracted from the signatures has a high percentage of identification error (40%), the statistical parameters chosen did not allow an efficient discrimination. The global character for describing a signature absorbs the particular characteristics some signatures may have. On the other hand, the
vector formed by the direct use of its measurements gave a better performance with an identification error of 1.5%. We focalized the next discussion on the second vector analyzed.

Although we obtained a high degree of identification, the confusion coefficient attained for each decision allows to see that an important quantity of good and bad decisions obtained were made with a high risk (Figure 9). We supposed that $CC \geq 0.75$ implies the ambiguous decision.

5. Conclusions

Through the results obtained we showed the high potential of biometrical approach for the identification of products by using the intrinsic characteristics of wood.

The algorithm developed is capable of a high degree of recognition in wood products. We know, for the time being, the different aspects to consider for increasing the actual performance of this algorithm. Certainly, the developed algorithm will depend closely on the transformation type that suffers the wood product, however, the algorithm developed in this first stage will be the base for future works. It is important to note the importance and the advantages that this type of identification system does have for current industries of wood, as it can be used during an important extension in the production line. The success of implementing this type of identification process will depend on finding the highest performance and reliability for the algorithm.

6. References


