Problems During Scientific Research and Designing Integration

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Abstract

This paper deals with experience and problems about research, project development with industry for IT solution design development. It is well known that design plays an increasingly important role in our daily lives. The University of Latvia and Joint Stock Company "Latvia's State Forests" within the framework of an effective collaboration projects program are developing joint research project. Partner was interested in development of an automatic volume measurement of logs and wood chip loads on trucks. To solve this problem, a methodology and a technological solution are needed to allow remotely perform volumetric surveys and monitoring. It is significant with the intense development of forest and logging industry. The system consists of measurement arch with video cameras and IT solution - video processing and analysis software, a graphical user interface, data communication channels and storage systems. When designing the timber assortment measurement line in field conditions, the specifics of its operation and high-performance requirements should be considered. Therefore, a laboratory prototype was made to evaluate arch size and size of its field of operation, the best cameras and light layouts. Was studied human experience in timber assortment manual measuring for better understanding IT solution design development. Graphical user interface design is developed taking into account the specific requirements of the partner - the integration of the indicators for the determination of the quality, as well as the easy to operate functionality in the geometric measurement process.

Keywords: *volume survey, laboratory prototype, measurement line, IT solution design*

1. Introduction

Nowadays, most of higher educational institutions are particularly interested in implementing joint projects with industry, sharing experiences and resources to jointly develop new technologies and innovative products. The collaboration research projects in the University of Latvia include the development and testing of new technology products and services for national economics, the involvement of new scientists and students in development processes, technology transfer and transfer of knowledge. Joint Stock Company "Latvia's State Forests" were interested in development of an automatic volume measurement of logs and wood chip loads on trucks.

The system consists of measurement arch with video cameras and IT solution - video processing and analysis software, a graphical user interface, data communication channels and storage systems. Video information is obtained from cameras that simultaneously acquire raw data from the object of the video processing area - both sides and top The information is transmitted to the external systems via data communication channels. The system will be used for automated volume measurement because in Latvia this process is currently performed by persons who manually measure loaded logs or wood chips on the trucks.

Presented research is focused on the measurement of log and wood chips volume loaded on truck by image analysis method. An automated log volume measurement and other techniques accuracy is very important because an amount of industrial wood being produced and transferred to wood working industry for further processing is growing. Till to nowadays the level of accuracy is not high still (Knyaz & Maksimov, 2014). West (2009), Davis (1990), Janak (2005, 2007) and other authors points out that the most part of techniques used in timber volume measurement are statistical coefficient and manual measurements – scalers use tape and ruler. Mainly the key element in these processes is operator (Knyaz & Maksimov, 2014). Several authors highlight that most methods for measuring the volume of round timber are developed more than 60 years ago, for example, piece-by-piece volume measurement, geometric group measurement, weight group measurement, etc. (West, 2009; Samoylov, 2006; Mehrentsev & Kruglov, 2017; Kruglov, Shishko, Kozhova, Zavada, 2017). Should be noted that in articles often are mentioned that even for piece-by-piece manual techniques errors can reach ±10% but using a measuring tape and a ruler - ±15% as well as that techniques are very time consuming (Knyaz & Maksimov, 2014; Janak, 2005, 2007).

More and more in different scientific articles authors emphasize that the IT (Information Technology) is developing very fast especially in the last decades and is rapidly entering a wide range of economic areas. IT for forest operations is used by selecting the suitable stand, harvesting operation, forwarding, storage and transport wood. Knowledge of information significantly influences planning, organization, control and duration of forestry works and improves the efficiency and performance of this sector (Gallo, Grigolato, Cavalli, Mazzetto, 2013; Kovácsová & Antalová, 2010). But data on the volume of timber give basic information for planning and control of production, purchase and sale and groundwork for remuneration, invoicing supplies, accounting and inventories, financing supplies and determining the productivity of stands (Sladek & Neruda, 2007).

It is well known that nowadays the technical equipment such as computers and video cameras, lasers, scanners etc. have become cheaper but personnel costs have increased. The high-tech equipment’s available on the market which can help to evaluate wood stacks, log and wood chips volume on trucks measuring methods. For example, in the measuring process of log stack often is used the photogrammetric technique which make this process more accurate, convenient, fast and well documented. It is aimed to eliminate manual measurement from control process and to provide objective and accurate volume estimation (Knyaz & Maksimov, 2014). It means that there is a demand for more rational wood measuring methods and it indicates that measurement will be more unmanned in the future (Börjegren, 2011).

One of the first photographic measuring system for the total volume of a loaded logs on a transport vehicle is described by R.B. Davis in 1990, he used two cameras whose geometric lens characteristics, separation distance and focal lengths were known. Stereo photographs were taken on each end of a load of logs. The photos of a logs are taken at a time when the transport vehicle normally is momentarily stopped. This invention, through the designed placement and orientation of the cameras, captures not only the imagery of the logs, but also the imagery of the delivery truck or train, plus a data display containing other information; such as date, time of day, load number, location, and any other information deemed necessary.

For the precise volume measurement result of loaded logs on truck some authors suggest paying attention to the accuracy of truck position as well as suitable cameras installation, for example in the scale houses, if it is good equipped with cameras that can record the front of the load as it arrives and the rear as it leaves (Stuckey & Magrath, 2007; Pásztory & Polgár, 2016). Cameras record every transaction that takes place in chronological order and the placement of cameras depend on what information is needed (Stuckey & Magrath, 2007). Different versions of manual and semi manual camera technology estimations of truck loaded pulpwood volume have been evaluated and reported to be efficient in M. Börjegren (2011) the method for volumetric measurement is called the 5:2-method where the weight of the load is used together with experience data and subjectively assessed factors of the actual load from the video stream.

Data on dimensions and shape of logs are also provided by microwave radiation scanners. Systems equipped with scanners are often used in sawmills where information of logs is processed by computers to produce a precise 3D profile of logs, from which its volume can be determined (West, 2009; Janák, 2012). For measuring the volume of timber load on a truck different laser measuring systems also are used, for example Modus 200, Logmeter 4000 (Moilanen, 2003; Nylinder, Kubénka, Hultnäs, 2008). The measurement was done by laser scanning the periphery of the load from both sides and from above. The truck is driven through the system at a fairly constant and low speed to get as good raw data as possible.

Different algorithms, software’s and platforms are developed for processing and analyzing the acquired information and data. Woodtech has developed algorithms to estimate length, diameter, stack volume and solid volume (Nylinder et al., 2008). The program for calculating the volume of round timber "FoRest" is designed to measure the volume and geometric characteristics of logs stacked in pile, to determine the pile volume by one or two images of the pile ends (Mehrentsev & Kruglov, 2017). Mobile platform Timbeter is based on image recognition and machine learning technology to determine the number of logs, volume and diameter of each log (Anonymous, 2018).

Many authors highlighted that main advantages of the photo analytical method, used in timber assortment volume measurement, are higher accuracy, faster measuring, easier documentation, stock registering opportunity, easy statistical report (Pásztory & Polgár, 2016).

The placement of video cameras and lighting, as well as the required dimensions of the arch of the measuring line for its creation in real field conditions were determined using a laboratory prototype. The log and wood chips transport vehicle models, 3D printer, small size video cameras, lights and created reduced size arch were used for system prototype tests.

It is well known that design plays an increasingly important role in our daily lives. In our research, science is closely related to design, for example in a laboratory prototype and graphical user interface designing. It should be emphasized that design is directly influenced by human experience, as well as design influences people's thinking.

2. Measurement Line Prototype

The project partner requirement determined to use only video cameras for acquisition the data needed for the process of log and wood chips volume measuring on trucks.

For designing the log and wood chips volume measurement line in field conditions, it is necessary to consider the specifics of its operation and the high requirements for performance its mostly applies to video cameras technical requirements. In order to ensure the maximum continuous operation of the volume measurement line, the influence of various environmental factors such as rain, wind, air temperature, etc. should be taken into account, which could limit the operation of the volume measurement line.

In addition to this resistance to climatic and environmental conditions, the performance of the video cameras is very important. Exiting the desired measurement line solution - passage arc, video cameras must have a sufficiently large viewing angle both vertically and horizontally so that the arch, on which the video cameras are fixed, should not be disproportionately high and wide.

The dimensions of the arch vary depending on the number of video cameras, the position and angle of view of the cameras, and the dimensions of the imported log and wood chips on trucks. Taking into account the known parameters of log and wood chips transport vehicle models the required arches dimensions were determined using the relationships of trigonometric functions (Figure 1).

To ensure homogeneous operation of the cameras for acquisition the same quality images, it must be positioned against the midpoint of the vertical axis of the sample to be measured. The required dimensions of the arch in field condition were defined by: taking into account that the usable height of the transport vehicle in real life does not exceed 3 m, the angle of view of the cameras used shall be at least 90° and the expressions of trigonometric functions.

By performing camera and lighting tests in laboratory conditions, the obtained raw data from video files were analyzed with video file analysis software to determine the best layout of cameras and lighting location in field conditions as well as the necessary dimensions of the measuring arch. In the tests were used six small cameras that were located at both sides of the log and wood chips transportation vehicle and at the top of measuring arch, see Figure 2 and Figure 3.

Figure 1: Examples of the Camera's Location Detection

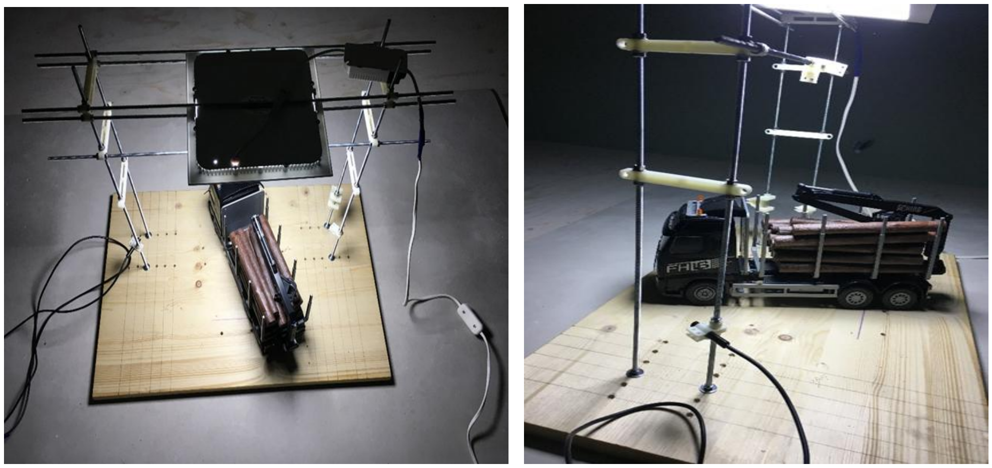

Figure 2: Testing Measurement Line Prototype

3. Setup for Raw Data Acquisition

Technical setup for data acquisition and processing is shown in Figure 4. Technical equipment for data acquisition consists of 6 video cameras, video storing unit. Data processing is performed by video processing unit and user PC.

Video cameras are installed as shown in Figure 5, standard video surveillance cameras are used. Such installation of cameras provides full vision of load on truck from different angles allowing to create a panoramic view of it, see Figure 6. Video data from all the cameras is transferred to video storing unit via Cat cables. Video recording is initiated by the time stamp of the master camera – camera who first sees the truck. All cameras are synchronized in time which allows to tie up data corresponding to one load. Afterwards data is processed by video processing unit. During the process panoramic images of load is created (detailed description of the process is given in next chapter) and provides the view of load from both sides as shown in Figure 6. These images are created using data from the side cameras which are installed on the vertical poles of the arch, see Figure 5. Data from these cameras are also used for creating the images of the middle and rear of load. Images shown in Figure 6 allows to measure the height and length of load. As well it is possible to measure the diameter of the logs in some cases but obtained results in such case is with poor accuracy.

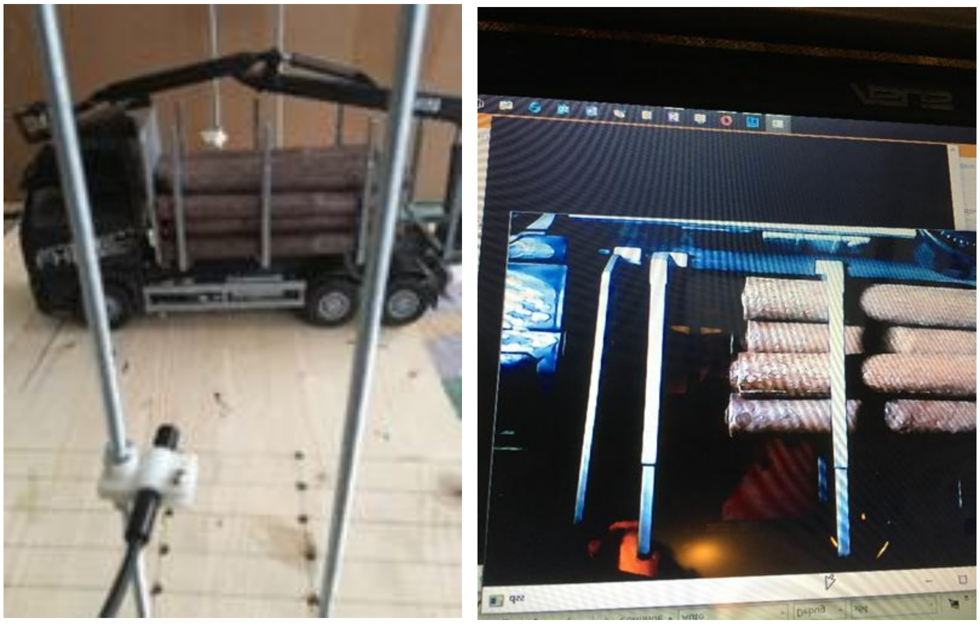

Figure 3: Raw Data Acquisition from Prototype

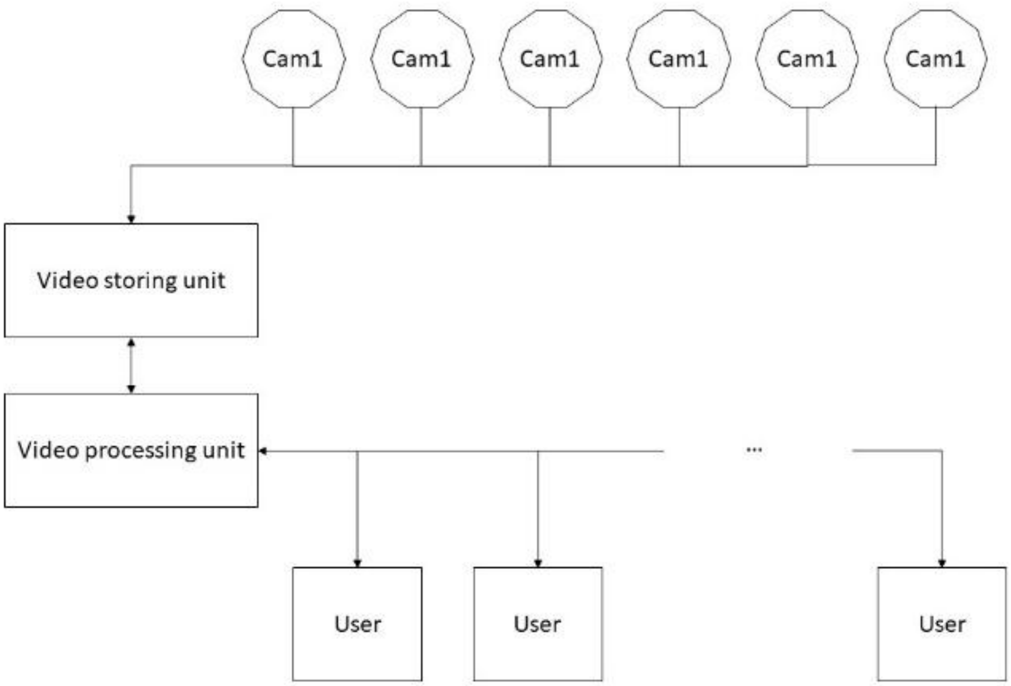

Figure 4: Technical Setup for Data Acquisition and Processing

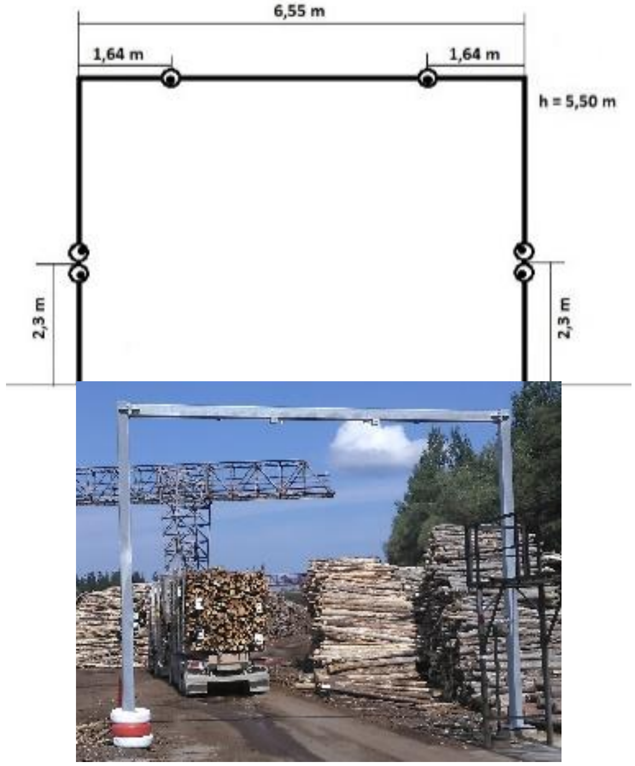

Figure 5: Installation of Cameras Project (left), Reality (right)

Figure 6: Panoramic View of Load

4. Processing and Analyzing of Raw Data

Several authors' articles highlighted different algorithms which today are capable of taking overlapping images of the same scene and quickly stitching them together to create panorama. Particular emphasis is placed that moving objects must be especially correctly handled, some authors recommends an invariant feature-based approach to fully automatic panoramic image stitching (Mills & Dudek, 2009; Hsieh, 2004; Shum & Szeliski, 2000; Brown & Lowe, 2007).

In the presented case, the raw data is obtained from the cameras which are placed at the angles defined by the prototype. In order to create the panoramic image correctly, the transformation images for each camera must be identified to ensure data processing. The image of the transformation is determined by marking four points in the video. In each of the video images a region of interest (ROI) is allocated, which includes the height of the load of truck and about 2 m in width, see Figure 7. Selected images should contain overlapping information. In the frame created on the image it is transformed accordingly.

Figure 7: Allocation of ROI in Video Images

Additionally, the control position in the image is determined, which determines whether the movement of the truck takes place in the picture. The control position for the area is determined by a normalized histogram, the change of which in the base of the histogram in the previous frames determines the beginning of the movement. The coordinates of the transformation images and the motion detection area coordinates for each video position are defined and fed to the data processing process. A vector file is created that gather basic information: video frames, pixels, coordinates of transformation, etc.

The aim of the data processing process is to create an image of a loaded truck panorama, see Figure 6. The panorama creation module which is built into the part of the automatic image processing and analysis software is used for the process of image matching. A truck in the data acquisition area, must move at a constant speed, the image may be distorted if the speed changes.

The movement of the object in the image is determined by the Farneback optical flow analysis algorithm (Farneback, 2000, 2001). The displacement of specific selected points in the frames are determined by the algorithm. In the case of data processing, this movement is analyzed for a transformed perspective image, and only the horizontal displacement is taken into account.

Algorithm determines the shift of the image in the frame compared to the previous frame. The red color in the illustration means the greatest displacement, the green means the smallest but the most significant movement. The minor displacement is depicted in black, see Figure 8.

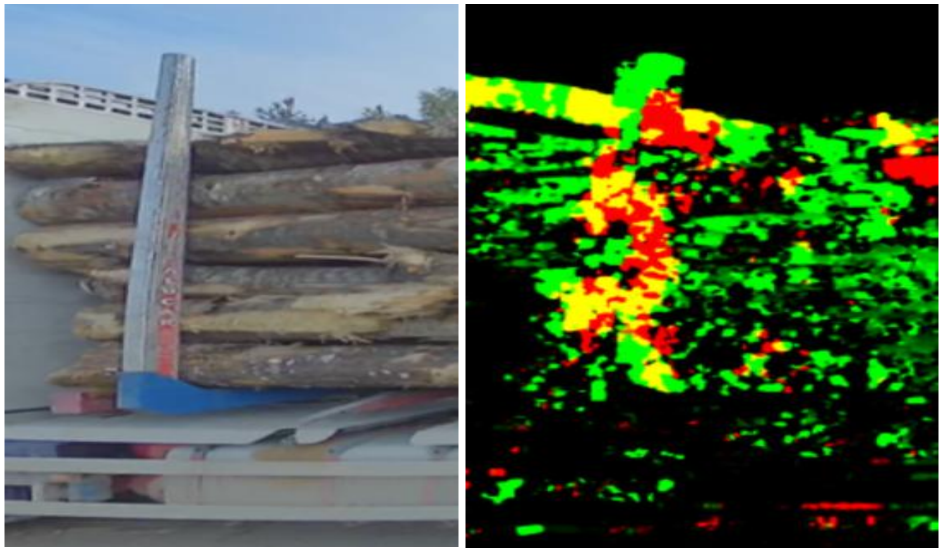

Figure 8: Example of the Shift Determination

In case of homogeneous points, the displacement may not be detected, the points for which the displacement is maximum are determined, however, it falls within the statistical deviation range. In addition to the obtained panoramic image, the direct transfer values are stored in each frame.

Data processing process to improve the detection of the location place of the rear of the truck and the front of the trailer in the video frames will be continued.

Cameras curvature rises to radial distortion at the periphery of the image. Building a panorama requires the images to be warped, using the computed homographies, into a common coordinate frame, and combined to form a single image (Capel, 2001).

A perspective transformation of two planes is based on the function which finds and returns the perspective transformation between the source and the destination planes.

5. Graphic User Interface

Coming to consensus on graphic user interface (GUI) of an IT solution for measurement process with a project partner was a hard goal to achieve. The needs of a partner changed from time to time and several iterations of designing the GUI were done. Considering that new needs can appear in future, GUI was designed with possibility to adapt it for partner or any customer needs. Although several iterations were done during the reconciliation of the final design of the GUI, a complete compromise was not reached as the partners' views on GUI design compliance with needs of the end-user differed.

Some screenshots of the GUI are presented in Figure 9. GUI have a lot of functions and possibilities. The GUI was developed with the integration of the indicators for the determination of the quality, as well as the easy to operate functionality in the geometric measurement process.

In general, the GUI was developed with the possibility to choose between two types of the loads (logs or wood chips), overall concept of the measurement process in both cases is realized in very similar manner. It was made with purpose to make trainings of the involved stuff easier and logically related. Both types of the measurements have integration of inner measurement standards of the partner for load quality (each of them consists of at least from 20 different quality coefficients which affects the volume of useful load).

GUI allows to measure such dimensions of the loads as height, width, length, diameter of logs, area of specified segment. As well it allows to automatically deduct scrapped wood volume from the total volume, display it as percentage of overall volume, show the area of scrapped wood, make measurements in several segments, etc. Process of the measurements is designed in the such way that the average value of the measurements is automatically calculated and displayed to the operator. It means that if the operator will measure the length of the load several times GUI will display the result which is the average value of all the measurements of corresponding dimension.

The process of the wood chips load measurements is a little bit different, as there is no so much dimensions to measure in this case, as well there is no necessity to determine the volume of scrapped wood chips.

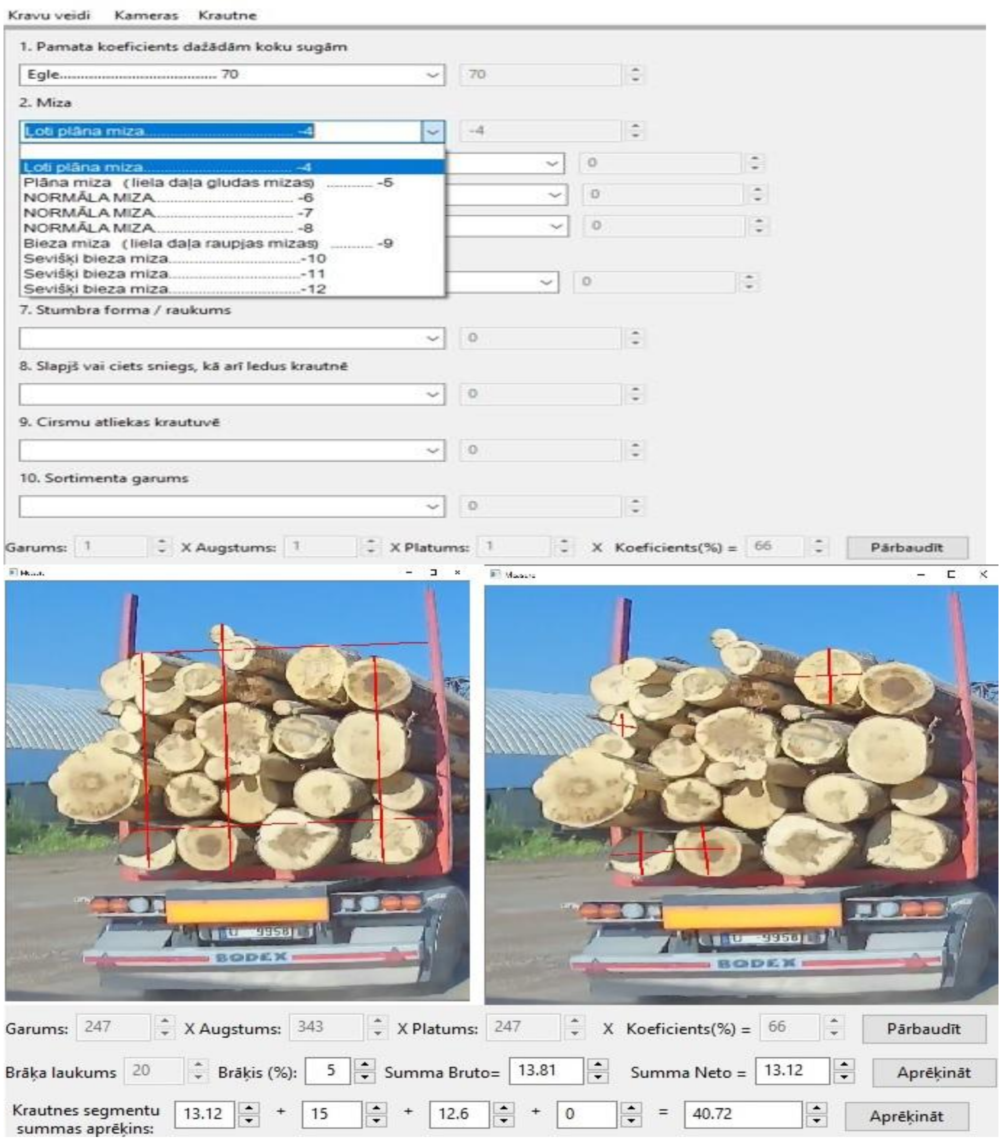

Figure 9: Graphic User Interface Screenshots

6. Conclusions

In the predesigning research was studied existing log and wood chips measurements, for example manual, semi-automated and automated. For the most precise measurement must to use laser or metric cameras, but in during research it was rejected by partner due to potentially high expenses, as well as with too much space requiring. That raised problems with wood chips measurement. Some problems were also with integration of partner requirements to choose non-metrics cameras. It led to more complex algorithms of panoramic image creation and in scaling - different number of pixels in vertical and horizontal planes. Passage arch was created, it gives impact of non-constant truck movement speed to accuracy of measurements. Using only 6 cameras often rises situation when it is not possible to see all what is necessary for creating panoramic scenes of loads with adequate accuracy. Additional problems were synchronization of cameras, trucks weren't going through the center of the measuring line arch causing different images from each side. Also, variable speed of the trucks led to different count in ROI of the panorama creation algorithm.

To better satisfy the needs of the partner it is reasonable to improve the appearance of the GUI making it more compliant to modern appearance of the applications' interface as it is predictable that other potential customers' point of view will be similar.

Any additional GUI functionality will be highly appreciated by the potential customers and end-users as well.

It is necessary to improve also the algorithms of scaling which are used for creation of panoramic images, as the field tests showed, that accuracy of current solution is subject to be improved. To a large extent this could be resolved by implementing the metric cameras into the current IT solution.

Scientific research and industry often have too different point of views. To achieve result which satisfies all the parties it is crucial to understand each other.

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