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Potato Classification by using Ultrasonic Sensor with LabVIEW

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ABSTRACT

Background: Agricultural product classification is an essential and widely working issue in the agriculture industry. There is a lot of work to be done in this area and the agriculture industry is looking for new applications. The reason is that the software and hardware Technologies are always developing and the latest technologies giving better results parallel to these developments. Also, the costs of the new technologies are decreasing with the help of low-cost sensor and device technologies. New technique and technology usage also directly related to classification efficiency. The primary data on agriculture are agricultural products, so these technologies and techniques use for agricultural production.

Methods: The primary data on agriculture are agricultural products, because of this reason, this research aimed to make ultrasonic sensor measurements with the help of a software which is developed in LabVIEW platform for potato classifications and showing the efficiency of the method for the potato classification, which has different sizes.

Result: According to the regression coefficient results, the regression between caliper length measurement (CL) and static ultrasonic sensor length measurement (SUL) found as 95.5%, the regression between caliper length measurement (CL) and dynamic ultrasonic sensor length measurement (DUL) found as 86.9%, the regression between static ultrasonic sensor length measurement (SUL) and dynamic ultrasonic sensor length measurement (DUL) found as 87.9% for potato classification.

Key words: Arduino, Classification, LabVIEW, Potato, Ultrasonic sensor.

INTRODUCTION

Sorting and classification issue is very critical for the agriculture industry because this issue effecting the qualities of the agricultural products, also dimension determination according to the sorting and classification standards. According to the standards and results, farmers get different incomes from sellers, so their decision effect the product prices. The latest techniques and technologies have to be used in agriculture by farmers and the agriculture industry with economic models.

One of the primary tasks of agricultural engineering is an improvement of the quality and quantity of agricultural production. For this aim latest techniques and technologies are used with economic models and their applications in agricultural fields. The main data on agriculture are agricultural products, so these techniques and technologies are use for best agricultural production.

The technical properties of the biological material are important for the agricultural machine and tool design, also improve the quality and quantity of agricultural products. Knowing the technical properties of biological materials gives information to the engineers how to develop agricultural tools and machines, also give a chance to succeed in product processing, additionally provide information for product quality control stages (Beyaz, 2008).

The aim of this paper is to make ultrasonic sensor measurements for the potato classifications, and detection the method efficiencies for potato classification, which has different dimensions. Nath and Shil (2018) were observed potato technological needs as post-harvest treatment (79.17%) which includes application sorting and grading, packing, curing *etc*. and method of fertilizer application (76.67%). These factors influenced by the parameters like product surface, also color changes affect the measurement results. Therefore, in this study, potatoes have selected which have different grading requirements. Potato dimension measurement values were obtained from ultrasonic sensor measurements. For this purpose, a low-cost ultrasonic sensor (HC-SR04) was used. And, the software was developed for real-time measurements on the LabVIEW platform. For the control of the result accuracy, obtained data were compared with the caliper measurements. As well as a comparative statistical test (regression test) was applied to the data, which is obtained from real-time static and dynamic ultrasonic measurements, also caliper measurements. Comparisons of the test results were used for explaining the effectiveness of the method for agricultural product dimension measurements at potato grading. According to the research data and comparison test, ultrasonic sensor classifications give good results for the agricultural product classifications. A consequence of these

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evaluations, the ultrasonic measurement process showed succesfull results in the agricultural product classifications, so it could be used efficiently as caliper measurements.

There are a lot of literature about the use of ultrasonic measurement applications and biological material properties. For example, Mohammed (2009) worked on ultrasonic and infrared sensor distance measurement by using LabVIEW software. He stressed that the ultrasonic sensor has a slightly higher resolution than that of the infrared sensor.

Hammad *et al*. (2007) studied a LabVIEW based experimental platform for ultrasonic range measurements. They say that their system has the advantages of flexibility and easy to use.

Naik and Panse (2012) researched about modeling of an ultrasonic sensor for range measurement. They presented that the correlation increases with the accuracy of time of flight measurements as compared to other detection methods when they use the Hilbert transform.

Stajnko *et al*. (2012) worked on programmable ultrasonic sensing system for targeted spraying in orchards. They accomplished prototype automated orchard sprayer that delivered pesticide, spray by using ultrasound sensors controlled with a microcontroller. They told that the programmable system is reducing the costs and environmental pollution.

Huang *et al*. (2012) were used ultrasonic and hall-effect sensors for a low-cost harvest area measurement system. Two ultrasonic sensors were used on both sides of the harvest divider to measure the cutting width and detect the crop presence at the start and end of harvesting.

Andújar *et al*. (2012) worked on weed detection in cereal crops by using an ultrasonic system. The system determined plant heights. Measurements of plant heights provided weed-infested zones where these zones have a higher amount of biomass than non-infested areas. The authors said that 'This system will potentially reduce the cost of weed detection and offers an opportunity for its use in non-selective methods for weed control'.

Sabancı *et al*. (2012) aimed to classify potatoes with the help of image processing techniques and artificial neural networks. Prior to the classification process, potatoes with deformations were detected by using the Otsu method and morphological processes, excluded from the classification. Then, the classification of the potatoes without problems was carried by them. For this purpose, small, medium, and large potato pictures were taken, and the system was trained by using Multi-Layer Perception Artificial Neural Networks. MATLAB software was used for image processing and artificial neural networks. The classification success of potatoes by using image processing techniques and artificial neural networks are examined.

Fisher and Sui (2013) studied with an inexpensive open-source ultrasonic sensing system for monitoring liquid levels. Occurred by an ultrasonic sensor, a microcontroller-based data logger, and a temperature sensor measures the distance from the sensor to the liquid surface. And also, they implied that the system could be adapted to a variety of other measurements.

Lijun *et al*. (2013) measured the greenhouse strawberry canopy by using ultrasonic sensors. As a result of this study, they told that the measuring system was stabilized and feasible.

Vidya Shree and Basappa (2017) used ultrasonic distance measurements for detaching water level with non-contact monitoring. They said that 'The advantages of the system are reduced at the wastage of the energy, the wastage of water, physical efforts and maintenance'.

Moeckel *et al*. (2017) studied on the estimation of biomass in grasslands with heterogeneous sward structure by using a fusion of ultrasound and spectral sensor data. They said that 'Fusion of ultrasound and spectral sensors is a promising approach to assess biomass even in heterogeneous pastures'.

Si *et al*. (2018) worked on potato tuber shape based on image processing. The developed acquisition system was integrated with an automated potato sizer to estimate potato tuber length to width (L/W) ratio. The system's success was ranged from 76 to 100% for the accuracies of L/W estimations.

Reddy *et al*. (2018) studied the morphological characterization of sweet potato cultivars during growth, development, and harvesting. As one of the physical parameters, they worked on tuber characters (skin and flesh colors, shape, weight, length, girth, number and yield per plant) after harvesting and they have recorded the standard description after 120 days growth period.

In light of this literature, in this research, potatoes that have different sizes were used as experiment material for the measurement method comparison with each other, with an application of the agricultural product classification. These methods are selected as caliper measurement (as primary measurement method), static and dynamic ultrasonic sensor measurements.

MATERIALS AND METHODS

Material

Potato samples, which are produced in Turkey, obtained from a local market in Ankara, the capital city of Turkey, were selected as the experimental material of the research. The aim of the selection of this product that they have different dimension classes as little, middle, and big. Little sizes are between 18 and 35 mm; middle sizes are between 35 and 80 mm; big sizes are between 80 and more than 80 mm, according to 2008 Turkish Standards TS 1222 (TSI, 2019). The samples of potatoes can be seen in Fig 1.

Method

LabVIEW Application

LabVIEW is a software that is developed for different aims with the various sub-modules for the goal of scientific usage. Among the various development platforms, LabVIEW offers

visual and easier software development techniques. Also, it has a vast programming library with engineering modules.

LabVIEW programming has two steps of visual programming. These are front panel for graphical objects and the block diagram for iconic programming. The front panel is an interactive software part where the user can insert visual and graphical objects in software like indicators and graphics. By the visual elements placed in this field, the interface of needed software can be created in a short time. Fig 2 shows the front panel of the application which have been developed by using LabVIEW.

The block diagram is the place where the iconic programming was done. Each icon has its source codes run in this location. The connections of these iconic codes create the program which we need. Software outputs can be seen from the front panel according to the entry and the exit of the software. Fig 3 shows the block diagram, which was developed by using the LabVIEW platform for the measurement application.

Ultrasonic measurement system

An alternative to the expensive systems to determine the dimensions of agricultural products, ultrasonic measuring systems also use for agricultural grading. In this application, designed ultrasonic measurement unit contain Arduino UNO R3 Development Board and ultrasonic distance sensors as main parts. Arduino UNO R3 Development Board has Arduino ATMega328 microcontrollers. It has 14 digital input-output pins, 6 PWM outputs and 6 analog DC input (Fig 4). The microcontroller on the board use sensor data for evaluating the results according to its program. Different connections can be use the purpose of prototype measurement units.

HC-SR04 ultrasonic distance sensors are used for the ultrasonic measurements (Fig 5). The sensor has a measurement capability of 2-400 cm. The sensor has, also, 3 mm precision measurement capability.

Electrical parameters belong to HC-SR04 Ultrasonic distance sensors can be seen in Table 1. Also, Arduino wiring

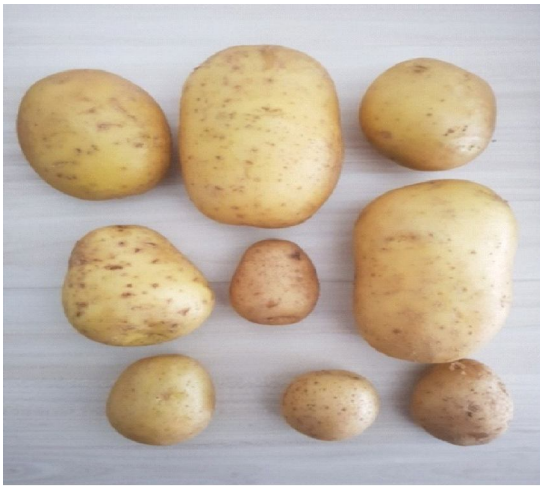


Fig 1: The samples of selected potatoes.

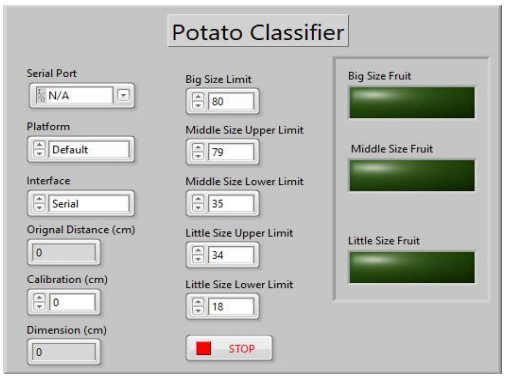


Fig 2: Software interface which is developed for ultrasonic sensor classification.

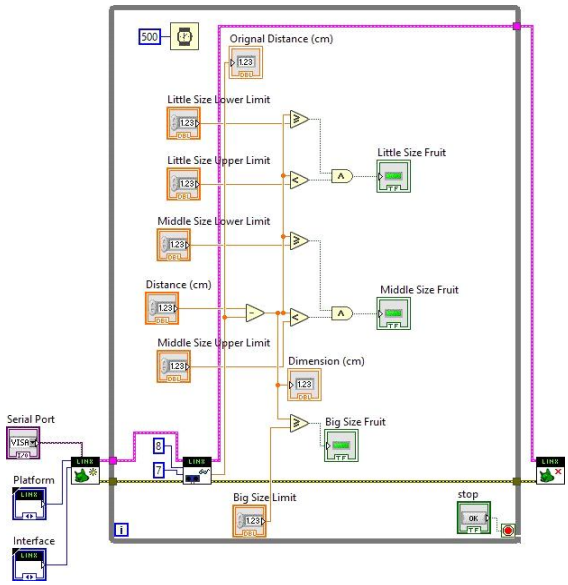


Fig 3: Ultrasonic measurement block diagram.

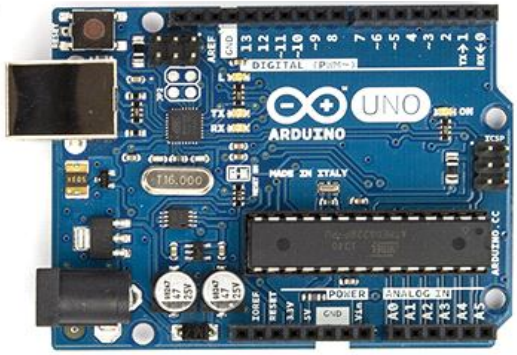


Fig 4: Arduino UNO R3.



Fig 5: HC-SR04 Ultrasonic distance sensor.

Table 1: Electrical parameters belong to HC-SR04 Ultrasonic distance sensor.

Parameter	Ultrasonic Sensor
Operating voltage	DC 5 V
Operating current	15 mA
Working speed	40 Hz
Max. Measure distance	4 m
Min. Measure range	2 cm
Measuring angle	15º

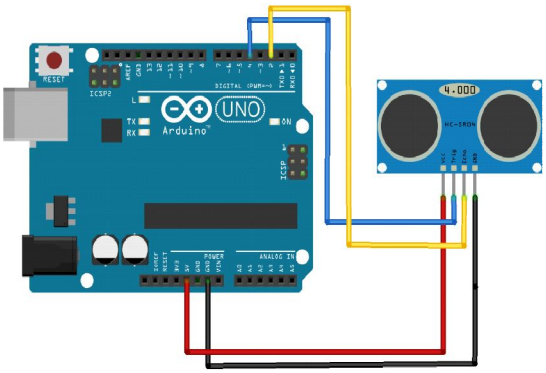


Fig 6: Arduino wiring diagram of the HC-SR04 ultrasonic sensor.

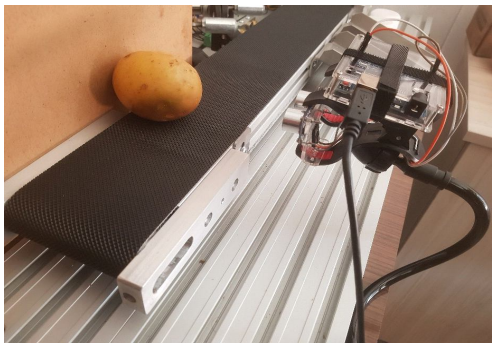


Fig 7: The measurement unit.

diagram of the HC-SR04 ultrasonic distance sensor can be found in Fig 6.

In this research, ultrasonic sensor measurements have been performed by 15 cm distance from the wood platform. The ultrasonic sensor measurement system was placed near a carrier band unit. In this way, static measurements were done while the carrier band is not working, and dynamic measurements were done while it's working. The measurement unit can be seen in Fig 7. The results compared with caliper measurements to check the accuracy of the determinations, and the difference between the results was analyzed statistically.

RESULTS AND DISCUSSION

Caliper and static-dynamic ultrasonic measurement technique length measurement values with the graphics which contain prediction equation, also the regression value of caliper and static - dynamic ultrasonic sensor measurements of potato samples can be seen in Fig 8-10.

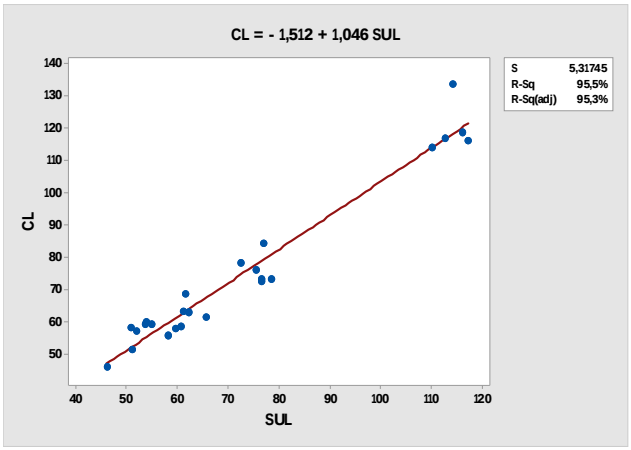


Fig 8: The graphic which includes prediction equation and the regression value of static ultrasonic sensor and caliper measurement of potato.

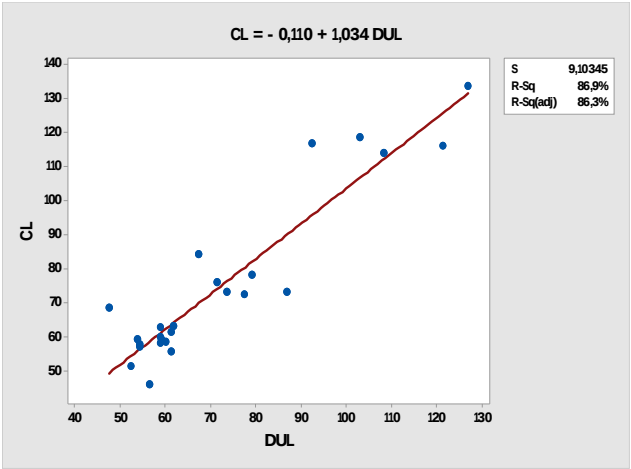


Fig 9: The graphic which includes prediction equation and the regression value of dynamic ultrasonic sensor and caliper measurement of potato.

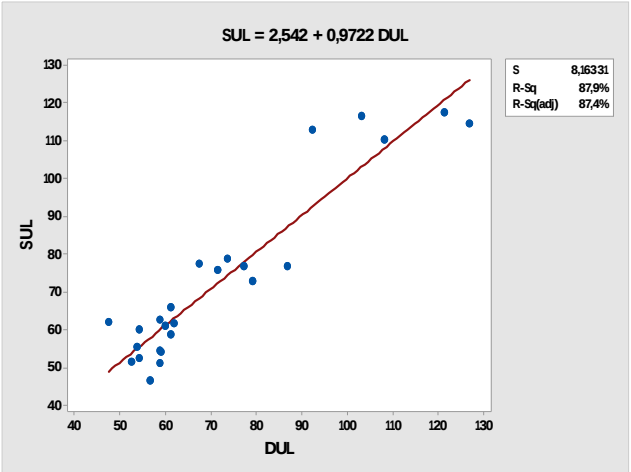


Fig 10: The graphic which includes prediction equation and the regression value of the static ultrasonic sensor and dynamic ultrasonic sensor measurement of potato.

Table 2: The grading results of potato by using the measurement unit.

CL	SUL	DUL	Class	SUL Results	DUL Results
83,90	77,04	67,35	Big	Middle	Middle
113,50	110,05	108,18	Big	Big	Big
68,20	61,73	47,61	Middle	Middle	Middle
62,70	61,22	61,90	Middle	Middle	Middle
133,10	114,14	126,90	Big	Big	Big
72,65	76,53	86,74	Middle	Middle	Big
116,25	112,60	92,36	Big	Big	Big
59,05	55,10	53,73	Middle	Middle	Middle
57,75	51,01	58,84	Middle	Middle	Middle
115,55	117,20	121,28	Big	Big	Big
72,20	76,53	77,35	Middle	Middle	Middle
77,70	72,45	79,09	Middle	Middle	Middle
57,30	59,69	54,20	Middle	Middle	Middle
118,10	116,18	103,08	Big	Big	Big
56,60	52,03	54,20	Middle	Middle	Middle
55,45	58,30	61,22	Middle	Middle	Middle
72,95	78,58	73,60	Middle	Middle	Middle
59,60	54,00	58,80	Middle	Middle	Middle
75,65	75,50	71,50	Middle	Middle	Middle
61,10	65,80	61,30	Middle	Middle	Middle
62,35	62,20	58,80	Middle	Middle	Middle
59,05	53,70	59,10	Middle	Middle	Middle
58,10	60,71	60,10	Middle	Middle	Middle
45,55	46,20	56,60	Middle	Middle	Middle
51,00	51,18	52,50	Middle	Middle	Middle
		Accuracy Percentile		96%	92%

Additionally, the grading results of potato by using the measurement unit can be seen in Table 2.

According to the regression coefficient results, the regression between caliper length measurement (CL) and static ultrasonic sensor length measurement (SUL) found as 95.5%, the regression between caliper length measurement (CL) and dynamic ultrasonic sensor length measurement (DUL) found as 86.9%, the regression between static ultrasonic sensor length measurement (SUL) and dynamic ultrasonic sensor length measurement (DUL) found as 87.9% for potato classification.

The results show that ultrasonic sensor measurement is an efficient measurement method for dimension measurements and classification of the potato samples.

CONCLUSION

In this research, ultrasonic measurement techniques have been excused. At first, essentials around the ultrasonic measurement were discussed for understanding the ultrasonic measurement and data acquisition system of LabVIEW. Then an application has been made. The results of real-time static – dynamic ultrasonic measurements show that the technique works fast and efficiently also the technique can be use in many fields in agriculture. When we await at this technology, we necessitate using computer and electronic-based systems. These systems promise a future as a solution for different kind of agricultural problems. For example, with Industry 4.0, IoT technologies place in the agricultural applications and all low-cost sensor types became more important in agriculture with the latest technologies like IoT. In this way, we can develope more efficient machine and tools for agricultural product sorting and classification.

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