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NON-CONTACT POINT MEASURING EQUIPMENT FOR ROBOTIC SYSTEMS OF AUTOMOBILE INDUSTRY

J Khollhujayev
TSTU, karimov913q@gmail.com

N Abdukarimov

J Mavlonov

N Abdivahidova

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References

1. Dergacheva, I. Problems of forecasting and prevention of transboundary floods in the mountainous and foothill regions of Uzbekistan [Electronic resource] / I. Dergacheva.- NIGMI, Uzhydromet.-Access mode: http://skachate.ru/geografiya/148685/index. html.- Date of access: 01.07.2017.
2. Uzbekistan railway. Current version. Versions, checked September 3, 2017 Internet materialari.
3. On measures to implement the Sendai Risk Reduction Program for 2015-2030 in the Republic of Uzbekistan // Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 299 of April 12, 2019.
4. Earthquakes and Volcanic Eruptions: A Handbook on Risk Assessment. Herbert Tiedemann. Swiss Re, Zurich, 1992.-951p.
5. Megacities: reducing vulnerability to natural disasters. Thomas Telford Publ., London, 1995.-170p.
6. Makhutov N.A., Reznikov D.O. Vulnerability assessment of technical systems and its place in the risk analysis procedure // Problems of risk analysis. Volume 5. – 2008. No. 3.– S. 76-89.
7. Methodological recommendations for assessing risks in the railway infrastructure of JSC "Russian Railways" -Moscow, 2011-109s.
8. Resolution of the President of the Republic of Uzbekistan dated February 19, 2007 No. PP-585 "On measures to prevent and eliminate the consequences of emergencies related to floods, mudflows, avalanches and landslides."
9. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On the state system of prevention and response to emergencies of the Republic of Uzbekistan" (December 23, 1997, No. 558);
10. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 427 of October 7, 1998 "On the procedure for preparing the population of the Republic of Uzbekistan for protection from emergencies."
11. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On the classification of man-made, natural and environmental emergencies" dated October 27, 1998, No. 455.
12. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 201 of April 12, 1994 on measures to prevent and eliminate the catastrophic consequences associated with floods, mudflows and landslides.
13. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On approval of the State Program for forecasting and prevention of emergencies" dated April 3, 2007 No 71.
14. Dergacheva, I. Problems of forecasting and prevention of transboundary floods in the mountainous and foothill regions of Uzbekistan [Electronic resource] / I. Dergacheva.- NIGMI, Uzhydromet. –Access mode: http://skachate.ru/geografiya/148685/index.html. – Date of access: 01.07.2017.
15. Khokhlov A.F. Ensuring the stability of the functioning of the Trans-Siberian railway in emergency situations. Collection of scientific papers - Moscow: MIIT, 2003. S. 53-55.
16. Khokhlov A. F., Ananiev V. P . The main directions of ensuring the stability of the functioning of railway transport in emergency situations. Interuniversity collection of scientific papers - M .: RGOTUPS, 2003, p. 89-93.

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NON-CONTACT POINT MEASURING EQUIPMENT FOR ROBOTIC SYSTEMS OF AUTOMOBILE INDUSTRY

J.M.Kholkhujaev[1*], N.A. Abdukarimov[1], J.R. Mavlonov[1], N.A. Abdivakhidova[1]
[1]*Turin Polytechnic University in Tashkent*

Abstract. *The non-contact measurement method development is caused by the need for precise measurement and elimination of an operator's errors. The purpose of the atticle research is to develop a reliable small scale prototype model of non-contact point measuring system. The mathematical model of robotic articulated arm has been developed to analyze the forward kinematics. Then, the prototype model of a robotic arm and laser-sensor mounted technique have been developed to take the measurements. The idea was derived from the coordinate measuring machine working principle, that puts the tip or tool center point in the known position with necessary precision. Most of the production engineers rely on the measurement data obtained from the CMMs. Most of the CMMs used in Uzbekistan are mainly contact based CMMs that have a number of disadvantages, i.e. a liitle inspection time. Also, the ergonomics and redundancy of the CMMs body frame are not acceptable. The surfaces of a vehicle body frame are designed in the free forms to give better aerodynamics and smaller resistance coefficients that result in difficult shapes that is not possible to reach easily with the ordinary CMM. The scientifically-developed robotic arm based on the non-contact CMM helps to cope with this issues.*

Key words: *: non-contact measurement equipment, flight laser time, inspection, forward kinematics, DH parameters, database, Arduino controller, best fit, circle, 3D scanning, automated systems*

Introduction.

Since last decades with the introduction of the image processing algorithms and laser technologies, the integration of non-contact methods of inspection, measurement and 3D modeling has increased sharply [1]. Also, currently used manual way of quality check do not provide appropriate accuracy and efficiency level[2]. The complexity of the manufactured products is another big issue that sometimes is not possible to directly measure the objects [3]. This triggered the development of semi-automated and automated systems of quality control [4].

Advanced technologies that is now commonly used in factories are the computer vision and optical measurement systems [5]. Among the most used systems are the laser based 3D acquisition method [6]. They are applied in the points where it difficult to get manually and also where the precision and productivity is important attribute [7].

In this paper, the main field of application is the automobiles body in white (BIW) dimensional accuracy measurement. Also, the system could be used in turbine blade, railway welding points and beads for active control [8]. The rapid development and integration of automation processes increases the importance of robotic positioning system [9].

The development of industrial robots with high flexibility of functions is deeply depend from sensor systems integrated into the process. The sensors that are used mainly for positioning are ultrasonic, microwave or optical [10]. Also, the fact that small and medium sized manufacturing cannot provide always with high cost systems triggers us develop a product that could help to be used in small production processes [11].

Dimension and point localization check is done by a different commercial based companies using laser triangulation, laser radar system and pattering technique [13][14]. However, these systems are too much complex and most of the car manufacturers omit using these machines only for inspection process.

The aim of the paper is to develop a low-cost automobile body measuring system that could give an appropriate results based on the data obtained.

1.1 Actuality of the issue

Shortening the launch time, the period from no production to full production, while simultaneously satisfying quality requirements, is a priority of the most advanced automobile manufactures, so does local car manufacturing company in Uzbekistan . Shortening launch time goes parallel with improving quality management, reducing the opportunity the work to be damaged and also the detection of defect occurrence. The detection of the defect plays one of the key roles in the automobile car production. One of most import aspects in the inspection plays the dimensional integrity of the automotive body (body in white) which has a great effect on the vehicle functionality and dynamics.

The inspection of an assembled car body in UzAutomotors Plant is mainly done according to visual analysis with the measurement of the differences on the surface and the inspection of gaps. However, not all the points that are crucial for the modern industry is checked for deviations from the coordinate frame of the car.

Today, with the advancements in the CAD technologies and 3D scanning the question of quality control rose to a new level. Most of the up to date automobile industries rely on the automated process of inspection that totally eliminate the operators error and greatly decreases the cycle time.

The aim of paper is to design, analyze and depict the key points for the development of the small prototype model of non-contact point measuring system that could be used with industrial robotic arm systems. That in near-future can be utilized as a method of on-line quality control and non-contact inspection of automobile assembly process in UzAutomotors.

3) Materials and Methods

a. Methods used in our system

The first thing was to design the mathematical model of the future non-contact point measuring system. The prototype model is aimed to be at first presentative than to be a small model of the actual non-contact point measuring system. The mathematical model of the robotic arm is of importance in this type of non-contact point measuring machine. Robotic arm itself is a branch of science in the robotics that are studied in different methods. Speaking about robots and particularly in this case the robotic arm one should first understand the science behind the movement of the robotic arm.

Rigid body transformation is characterized by the fact that they preserve the distance between points. Suppose we have two points in the rigid body with position vectors v1 and v2

$$(v1-v2)*(v1-v2)=(v1-v2)T*(v1-v2) \qquad (1)$$

After a transformation of the body the points will have new positions, say, v1’ and v2’. The new points will be separated by distance:

$$(v1'-v2')*(v1'-v2')=(v1'-v2')T*(v1'-v2') \qquad (2)$$

So if :

$$(v1-v2)*(v1-v2)= (v1'-v2')*(v1'-v2') \qquad (3)$$

For every points v1 and v2, the transformation is rigid. We begin by looking at 2D or planar transformations. A robot manipulator consists of several links connected by, usually, single degree of freedom joints, say, a revolute or a prismatic joint. In order to control the end-effector with respect to the base, it is necessary to find the relation between the coordinate frames attached to the end-effector and the base Symbol Terminologies or DH parameters [15]:

θ: A rotation about the z-axis.

d : The distance on the z-axis.

a : The length of each common normal (Joint offset).

α: The angle between two successive z-axes (Joint twist)

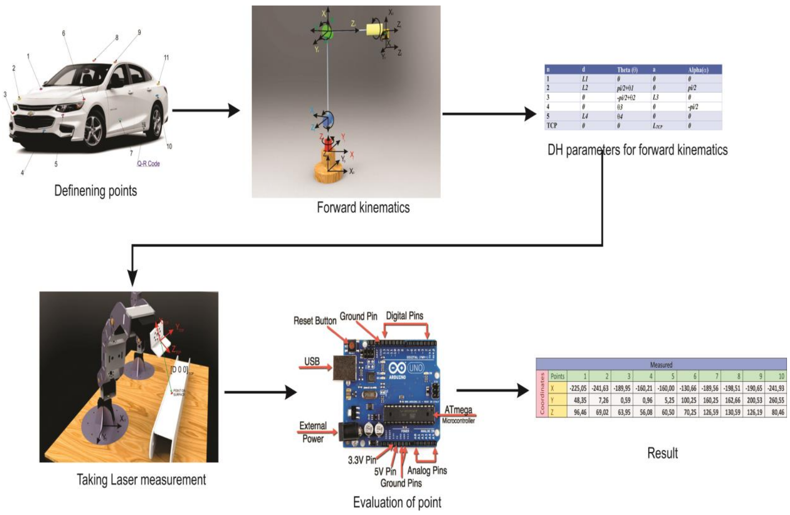

Figure 1. 3D revolute joints and links CAD model

Laser distance meter. The VL53L0X is a new generation Time-of-Flight (ToF) laser-ranging module housed in the smallest package on the market today, providing accurate distance measurement whatever the target reflectance's unlike conventional technologies. It can measure absolute distances up to 2 m, setting a new benchmark in ranging performance levels, opening the door to various new applications.The VL53L0X integrates a leading-edge SPAD array (Single Photon Avalanche Diodes) and embeds ST's second generation FlightSenseTM patented technology[16]

The VL53L0X's 940nm VCSEL emitter (Vertical Cavity Surface-Emitting Laser), is totally invisible to the human eye, coupled with internal physical infrared filters, it enables longer ranging distance, higher immunity to ambient light and better robustness to cover-glass optical cross-talk.

The Robotic Arm Design . The links are made of plastic material that has a quite good material hardness properties and mainly small elongation coefficients. The material that was chosen was an acrylic material that gave esthetic view, but the main reason is the fact that it is readily available and easily cut on laser cutting machine with precision of a few microns.

The measurement. The measurements are done based on the methodology of first taking all going to predefined point based on the forward kinematics method , afterwards the distance in 1D is taken from laser. Then, the data from 1D is transformed into point in last coordinate frame. This frame then transformed into base coordinate through DH parameters.

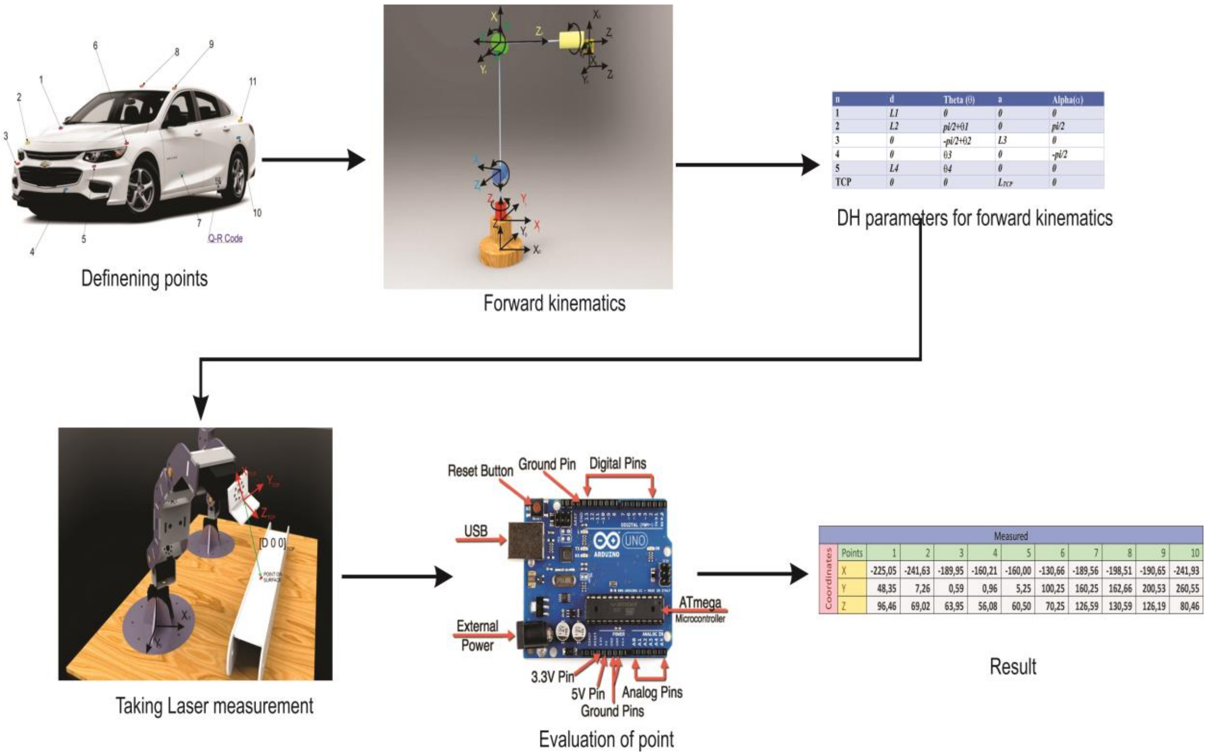

Figure 2 The measurement algorithm used in the research to evaluate the points

From figure 4, it can be seen the measurement algorithm used during the research .

b. Evaluation of measurement data

Thesis aims to highlight the project that mainly focuses on the mechanical measurements and statistical analysis of the data obtained through the prototype model of non-Coordinate Measuring Machine. Therefore, the measured data analysis in the CMM plays the vital role following its basic and raw idea of "measuring the coordinate".

"No measurement is, or ever can be, exactly right" this saying in metrology refers to the fact that all measurements of physical quantities are subjected to uncertainties in the measurements. The main reason is the physical property of bodies and also variables that affect the measurement results are impossible to hold constant.

Uncertainty is the component of a reported value that characterizes the range of values within which the true value is asserted to lie. An uncertainty estimate should address error from all possible effects (both systematic and random) and, therefore, usually is the most appropriate means of expressing the accuracy of results. This is consistent with ISO guidelines.

It is vital in commercial and health care areas to provide an interval about the measurement result in order to give the information to be able to compare with reference or the other ones. Uncertainty is this interval or parameter associated with the result of a measurement, that characterizes the dispersion of the values that could reasonable attributed to the measurement.

MEASUREMENT=(BEST ESTIMATE±UNCERTAINTY) units

Any measurement has got the form as above in order to assure the reliability.

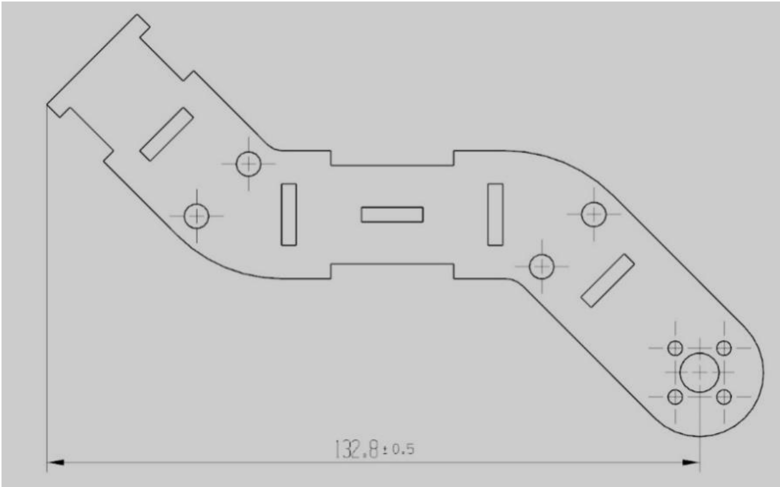

Figure 3Uncertainty in the measurement

As one can see from the figure 30 the measurement uncertainty is ±0.5mm here. So, for this project is important to have an uncertainty as small as possible.It is therefore necessary that there be a readily implemented, easily understood, and generally accepted procedure for characterizing the quality of a result of a measurement, thatis, for evaluating and expressing its uncertainty.

The main issue in this stage of project is to evaluate properly themeasurand and uncertainty associated with D-H parameters of length L1, L2, L3, L4, L5 and a1.The case of interest is where the quantity Y being measured, called measurand, is not measured directly, but is determined from N other quantities X1, X2, X3,…XNthrough a functional relation f, often called the measurement equation:

Y = f(X1, X2, . . . , XN)

However, there are two types of uncertainty associated with the repeated measurements. Uncertainty is categorized according to the method used to evaluate them:

Type A: uncertainty based upon the statistical analysis of data

Type B: the other methods except statistical analysis

Type A standard uncertainty can be evaluated based on real data observation repeating the measurements, while Type B standard uncertainty is obtained through a prior belief on probability density function.

As one can understand our case is for sure the Type A standard uncertainty evaluation method as be do not have any prior belief about the measurements. Therefore, here below is the procedure of evaluation of measurand and associated uncertainties.

$$x_m = \sum_{k=1}^{n} X_{i,k}$$

This average is the best available estimate of the width of the piece of paper or the length of a link, but it is certainly not exact. We would have to average an infinite number of measurements to approach the true mean value, and even then, we are not guaranteed that the mean value is accurate because there is still some systematic error from the measuring tool, which can never be calibrated perfectly. So how do we express the uncertainty in our average value?

The standard uncertainty s to be associated with xi is the estimated standard deviation is :

$$s = \sqrt{\frac{(\sum_{k=1}^{n}(x_i - x_m)^2)}{N-1}}$$

The significance of the standard deviation is this: if you now make one more measurement using the same meter stick, you can reasonably expect (with about 68% confidence)

The evaluation methodology is simply based on matrix transformation in 3D. This distances just represent the [-D 0 0] point in the coordinate frame of TCP. Now objective is to transform vector

[-D 0 0] that is in TCP coordinate into base coordinate frame and compare the results with the Nominal one.

In order to transform coordinate frame, we will need for each point exactly the angle of joint variables. The angle of joint variables are easily taken from the Arduino program code for each point specified.

Likewise for each function we almost the same approach, in that way we could easily use his functions by accessing them directly. So, the results are quite interesting.

Measured											
Coordinates	Points	1	2	3	4	5	6	7	8	9	10
	X	-225,05	-241,63	-189,95	-160,21	-160,00	-130,66	-189,56	-198,51	-190,65	-241,93
	Y	48,35	7,26	0,59	0,96	5,25	100,25	160,25	162,66	200,53	260,55
	Z	96,46	69,02	63,95	56,08	60,50	70,25	126,59	130,59	126,19	80,46
Nominal											
Coordinates	Points	1	2	3	4	5	6	7	8	9	10
	X	-225,47	-238,52	-194,06	-165,02	-147,91	-136,02	-192,99	-209,64	-195,16	-242,54
	Y	46,09	10,27	-7,09	-2,02	8,41	101,52	158,24	168,82	194,05	266,94
	Z	102,16	76,62	68,04	60,52	68,46	67,18	131,50	131,86	130,71	83,88
Precision		0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Deviation from Nominal											
Coordinates	Points	1	2	3	4	5	6	7	8	9	10
	X	-0,42	3,11	-4,10	-4,81	12,09	-5,36	-3,43	-11,13	-4,50	-0,61
	Y	-2,27	3,00	-7,68	-2,97	3,16	1,27	-2,01	6,16	-6,48	6,39
	Z	5,70	7,60	4,09	4,44	7,96	-3,07	4,91	1,27	4,52	3,42
Tolerance		9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00	9,00

Table 1. The results obtained from measuring

The tolerances are written according to the GM standards on the car body analysis. It is important to cope with the standards of Gm Uzbekistan, because if we will going to realize a project in the plants we should be able to design the product in the tolerance.

Tolerance in GM is given to the vector and also to each point the assembled car. Nominal points in the company are taken according to the 3D CAD model of each Automobile produced in the company. Therefore, below in the table 1 one can see the deviations from the nominal data points. Red grids are the points where we could not achieve the necessary tolerance as a result of geometric deviations in our small car model or the errors in the measurement of the exact angle in the process.

4) Conclusion

Results from a small-scale model of future-industrial robot has shown that it can be easily implemented with the big-scale real time robotic arm non-contact measurement machine. The application of non-contact CMM greatly enhances the available methods of inspection of an assembled car technology giving a number of advancements that is listed below:

- Total elimination of an operator's error and interaction in the inspection process of assembled car (Automation of a process)
- Increase of the speed of inspection process compared to the existing operator visual analysis
- Leveling up the precision standards on the car body, increase of quality of car body surface
- Availability of online results on computer servers

Implementing this kind of tool in the UzAutomotors plant will not just increase the quality of the products produced, but maybe help to apply automation in the quality control system of UzAutomotors and decrease the cycle time of each car produced.

Quality of products depends on various factors. The production of automotive parts, medical devices, sport equipment's or any other body parts has to be controlled in all phases of production.

The aim of the thesis is to show a new approach toward the enhancement of the production process and inspection systems. Future project that is going to be based on this small scale project and thesis will totally change the inspection process in the plant.

Reference

1. Zhifeng Zhang, Yusheng Zhai, Zhan Su, Lin Qiao, Yiming Tang, Xinjie Wang, Yuling Su, and Zhijun Song "Research on high-precision laser displacement sensor-based error compensation model", Proc. SPIE 9623, 2015 International Conference on Optical Instruments and Technology: Optoelectronic Measurement Technology and Systems, 96231A (7 August 2015)
2. Zhifeng Zhang, Qibo Feng, Zhan Gao, Cuifang Kuang, Cheng Fei, Zhang Li, Jinyun Ding, "A new laser displacement sensor based on triangulation for gauge real-time measurement," Optics & Laser Technology, vol. 1, is. 40, pp. 252-255, 2008.
3. Hsueh-Liang Huang, Wen-YuhJywe, Chien-HungLiu, LiliDuan, Ming- ShiWang, "Development of a novel laser-based measuring system for the thread profile of ballscrew," Optics and Lasers in Engineering, vol. 1, is. 48, pp. 1012-1018, 2010.
4. Jure Rejc, JustinCˇinkelj, MarkoMunih, "Dimensional measurements of a gray-iron object using a robot and a laser displacement sensor," Robotics and Computer-Integrated Manufacturing, vol. 1, is. 25, pp.155-167, 2009.
5. A. Cigada, F. Mancosu, S. Manzoni, E. Zappa, "Laser-triangulation device for in-line measurement of road texture at medium and high speed," Mechanical Systems and Signal Processing, vol. 1, is. 24, pp. 2225-2234, 2010.
6. P. Schalk, R. Ofner, P. O'Leary, "Pipe eccentricity measurement using laser triangulation," Image and Vision Computing, vol. 1, is. 25, pp.1194-1203, 2007.
7. F.J. Brosed, J.J. Aguilar, D. Guillomía, J. Santolaria, "3D Geometrical Inspection of Complex Geometry Parts Using a Novel Laser Triangulation Sensor and a Robot," Sensors, vol. 1, is. 11, pp. 90-110, 2011.
8. V. Niola, C. Rossi, S. Savino, S. Strano, "A method for the calibration of a 3-D laser scanner," Robotics and Computer-Integrated Manufacturing, vol. 1, is. 27,pp. 479-484, 2011.
9. R.G. Lyons, Understanding Digital Signal Processing, New Jersey: Pearson Education, Inc., 2011.
10. Zhongxue Gan, Visual Sensing and its Applications, Hangzhou: Zhejiang University Press, 2011.
11. Alexander Reiter, Andreas Müller, Hubert Gattringer, "On Higher Order Inverse Kinematics Methods in Time-Optimal Trajectory Planning for Kinematically Redundant Manipulators", *Industrial Informatics IEEE Transactions on*, vol. 14, no. 4, pp. 1681-1690, 2018.

12. Andrea Giusti, Jörn Malzahn, Nikolaos G. Tsagarakis, Matthias Althoff, "On the Combined Inverse-Dynamics/Passivity-Based Control of Elastic-Joint Robots", *Robotics IEEE Transactions on*, vol. 34, no. 6, pp. 1461-1471, 2018.
13. Dominik Kaserer, Hubert Gattringer, Andreas Müller, "Nearly Optimal Path Following With Jerk and Torque Rate Limits Using Dynamic Programming", *Robotics IEEE Transactions on*, vol. 35, no. 2, pp. 521-528, 2019.
14. Xin Jing, Haibo Gao, Zhengsheng Chen, Yaobing Wang, "A Recursive Dynamic Modeling and Control for Dual-arm Manipulator With Elastic Joints", *Access IEEE*, vol. 8, pp. 155093-155102, 2020.

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PASTEURIZATION OF POMEGRANATE JUICE BY EXTREMELY HIGH-FREQUENCY ELECTROMAGNETIC FIELD ENERGY.

J. M. Kurbanov[1], N. R. Barakaev[2], A.O. Uzaydullaev[3]*
[1]Samarkand economical and service institute, [2]Bukhara engineering technology institute,
[3]Gulistan State University

Abstract: *The following article presents the results and data of an experimental study on pasteurization of pomegranate juice by using extremely high frequency electromagnetic field energy. In the EHF process research, a camera, the precise measurement of the product temperature is of great importance since it is impossible to measure it with mercury, thermometers and other types of thermometers.*

Therefore, we used a special air dioxide thermometer during the research process.

As it is already mentioned above, the ratio of comparable capacities: ingested in the cell and in the intercellular environment, basically means the effectiveness of the EHF EMF thermal effect.

The t_{δ} *magnitude denotes the ratio of the minimium of the validity of dielectric conductivity. The same* t_{δ} *coefficient indicates the warming intensity of the cell in relation to the environment.*

Key words*: extremely high frequency, electromagnetic field energy, resonator chamber, air-cooled dioxide thermometer, dielectric permeability, pasteurization, cell, microorganisms.*

Nowadays, the world's production of pomegranate fruit amounted to 3,086 million tons. In particular, "in 2016, India – 900 thousand t, Iran – 800 thousand t, China – 290 thousand t, Turkey – 220 thousand t, USA – 200 thousand t, Pakistan – 120 thousand t, Afghanistan – 90 thousand t, Tunisia – 85 thousand t, Azerbaijan – 82 thousand t, Syria – 79 thousand t,Uzbekistan-60 thousand t were harvested" [1]. Therefore, many scientific works are aimed at the implementation of technologies aimed at the rapid development of pomegranate fruit processing, the production of juice, [2] concentrate and other assortment products.

In the food industry of our republic a wide range of scientific developments on the introduction of technology of storage and processing of fruits and vegetables, production of exporting capacity juices have been prepared and introduced into production. [3] In the strategy of actions on further development of the Republic of Uzbekistan, the tasks of "Deepening structural changes and consistent development of agricultural production, further strengthening of food security of the country, expansion of production of environmentally friendly products, significant increase of export potential of the agrarian sector" [4] are defined. In this regard,