Faculty of Electronics, Telecommunications and
Information Technologies
Politehnica University Timisoara

Optical Distance Measurement Online Data Evaluation at Different Positions Using Six Sigma Tools

Roland Szabó, Aurel Gontean

4th Hungarian Future Internet Conference and Smart City Exhibition
Budapest University of Technology and Economics, November 8-9, 2017

Content (1)

Content (2)

1. Introduction (1)

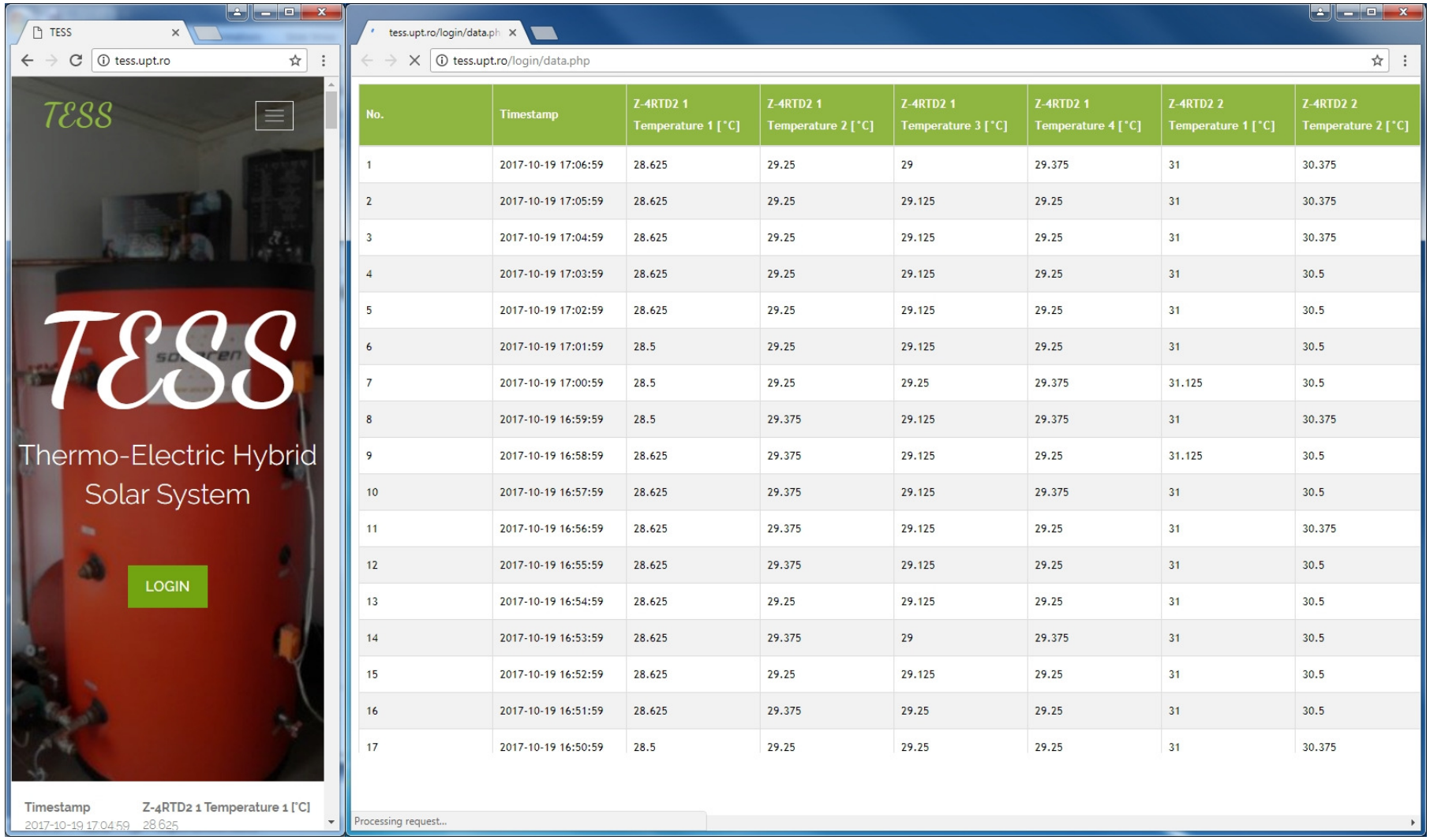
- This paper presents an optical distance evaluation with the help of Six Sigma. With the help of statistical tools it can be evaluated any measurement systems and can be easily made an MSA (Measurement System Analysis).
- Like every measurement system optical distance measuring can have errors, apparently bigger than traditional systems. Six Sigma tools can evaluate the measurement system and can give useful data about its accuracy. Sometimes measurement system evaluation is done twice.
- First there are done initial tests, after there is made some fine tuning and error correction and finally a repeated test, to show that the measurement errors were corrected.

1. Introduction (2)

- Optical distance measurement is often used in robotics ore other high tech equipments where precision is a key function.
- All the data is stored online in an SQL database.
- This can help to getter better access to the data and can improve to have a better data evaluation with graphs both online and offline.

- Webpage: tess.upt.ro

2. Webpage and Database



No.	Timestamp	Z-4RTD2 1 Temperature 1 [°C]	Z-4RTD2 1 Temperature 2 [°C]	Z-4RTD2 1 Temperature 3 [°C]	Z-4RTD2 1 Temperature 4 [°C]	Z-4RTD2 2 Temperature 1 [°C]	Z-4RTD2 2 Temperature 2 [°C]
1	2017-10-19 17:06:59	28.625	29.25	29	29.375	31	30.375
2	2017-10-19 17:05:59	28.625	29.25	29.125	29.25	31	30.375
3	2017-10-19 17:04:59	28.625	29.25	29.125	29.25	31	30.375
4	2017-10-19 17:03:59	28.625	29.25	29.125	29.25	31	30.5
5	2017-10-19 17:02:59	28.625	29.25	29.125	29.25	31	30.5
6	2017-10-19 17:01:59	28.5	29.25	29.125	29.25	31	30.5
7	2017-10-19 17:00:59	28.5	29.25	29.25	29.375	31.125	30.5
8	2017-10-19 16:59:59	28.5	29.375	29.125	29.375	31	30.375
9	2017-10-19 16:58:59	28.625	29.375	29.125	29.25	31.125	30.5
10	2017-10-19 16:57:59	28.625	29.375	29.125	29.375	31	30.5
11	2017-10-19 16:56:59	28.625	29.375	29.125	29.25	31	30.375
12	2017-10-19 16:55:59	28.625	29.375	29.125	29.25	31	30.5
13	2017-10-19 16:54:59	28.625	29.25	29.125	29.25	31	30.5
14	2017-10-19 16:53:59	28.625	29.375	29	29.375	31	30.5
15	2017-10-19 16:52:59	28.625	29.25	29.125	29.25	31	30.5
16	2017-10-19 16:51:59	28.625	29.375	29.25	29.25	31	30.5
17	2017-10-19 16:50:59	28.5	29.25	29.25	29.25	31	30.375

Fig. 1. Webpage and database with measurement data – tess.upt.ro

3. Measurements Table

Table I. Distance measurement using cameras at different distances [mm] highlighting measurement error [mm]

Real Distance [mm]	Computed Distance [mm]	Delta [mm]
100	99	1
200	202	-2
300	303	-3
400	395	5
500	502	-2
600	598	2
700	699	1
800	797	3
900	904	-4
1000	1005	-5
1100	1101	-1
1200	1204	-4
1300	1298	2
1400	1402	-2
1500	1494	6
1600	1599	1
1700	1701	-1
1800	1802	-2
1900	1905	-5
2000	2005	-5
2100	2105	-5
2200	2202	-2
2300	2302	-2
2400	2404	-4
2500	2496	4
2600	2598	2
2700	2697	3
2800	2796	4
2900	2902	-2
3000	3006	-6

4. Histogram

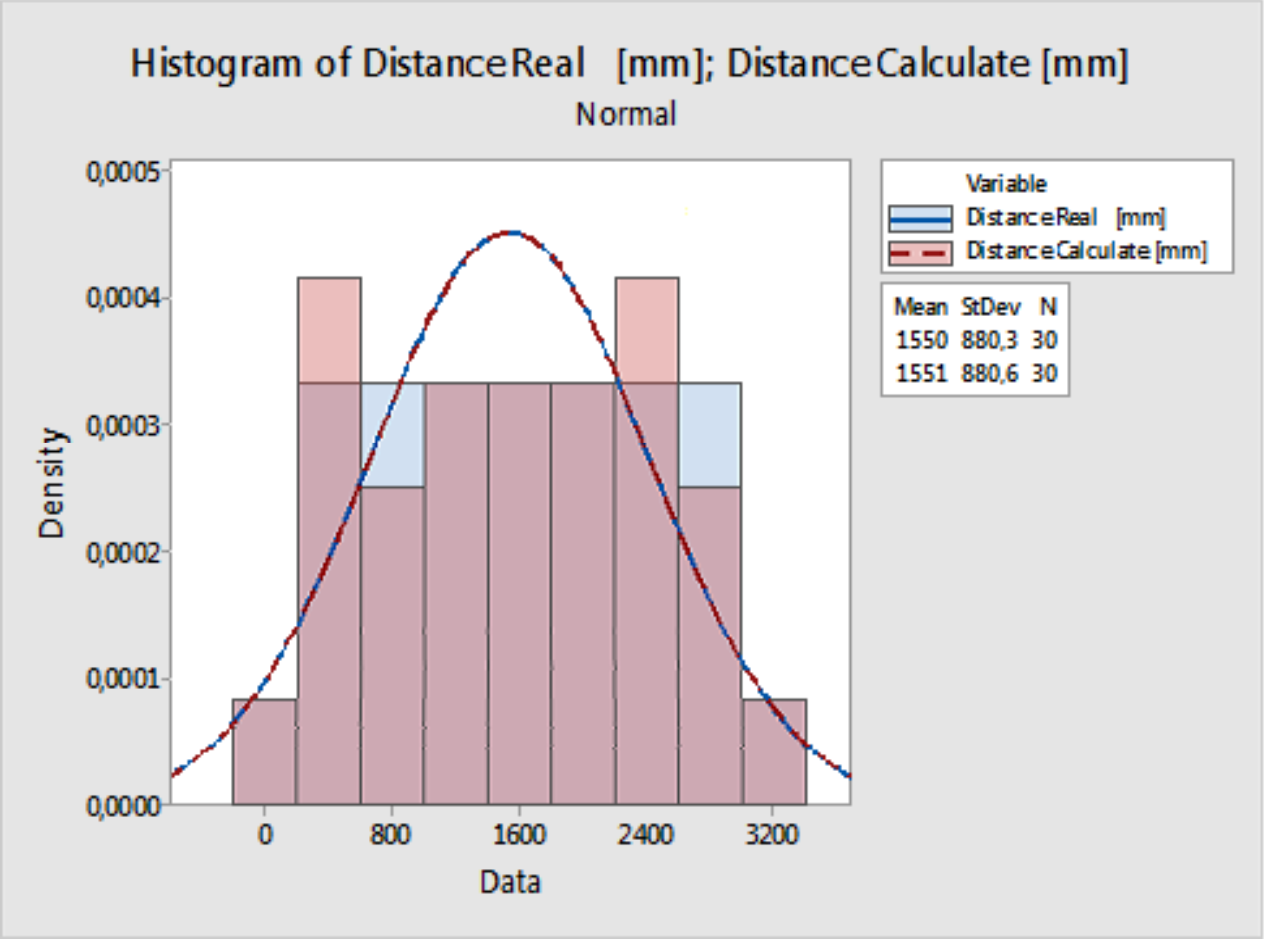


Fig. 2. Histogram of actual real distance and the distance computed by the system using cameras

5. Probability Plot of Distances

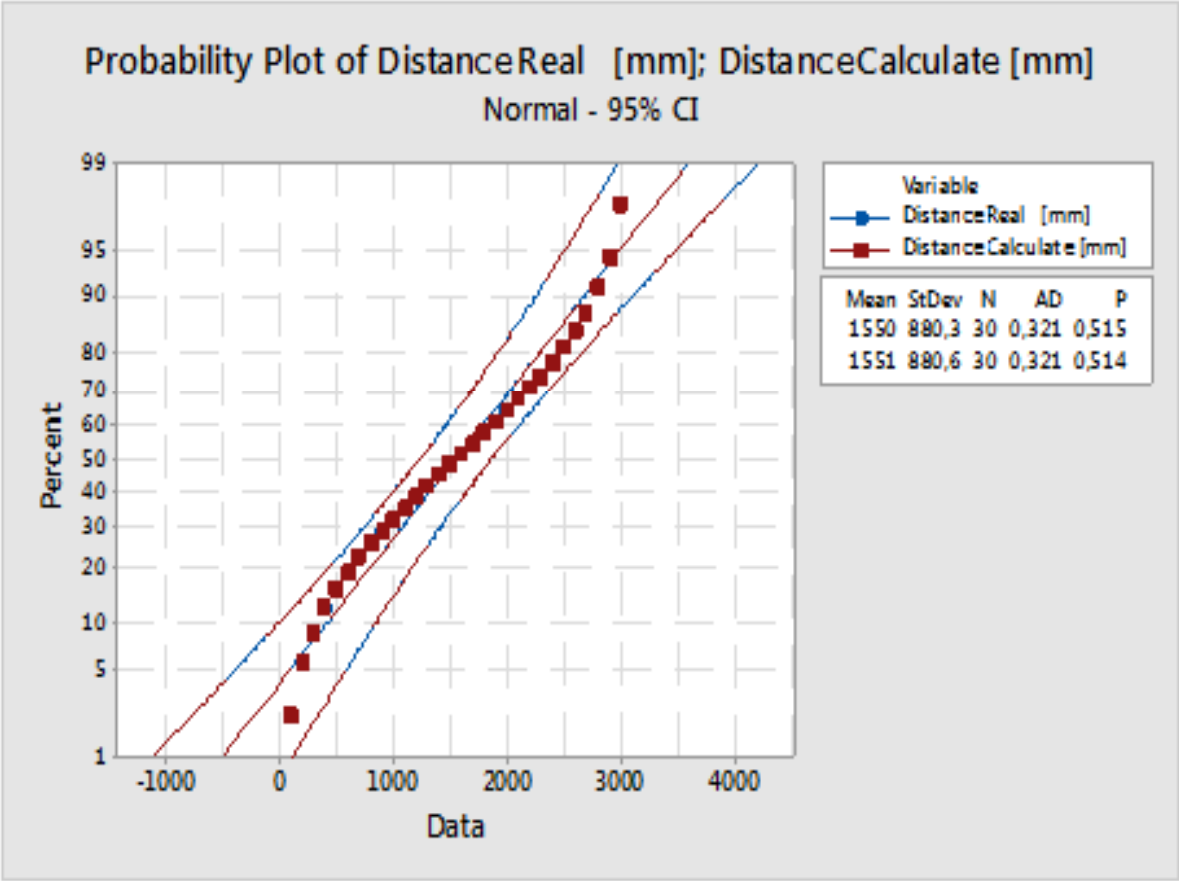


Fig. 3. The normal probability plot the actual real distance and the distance computed by the system using cameras

6. Probability Plot of Delta

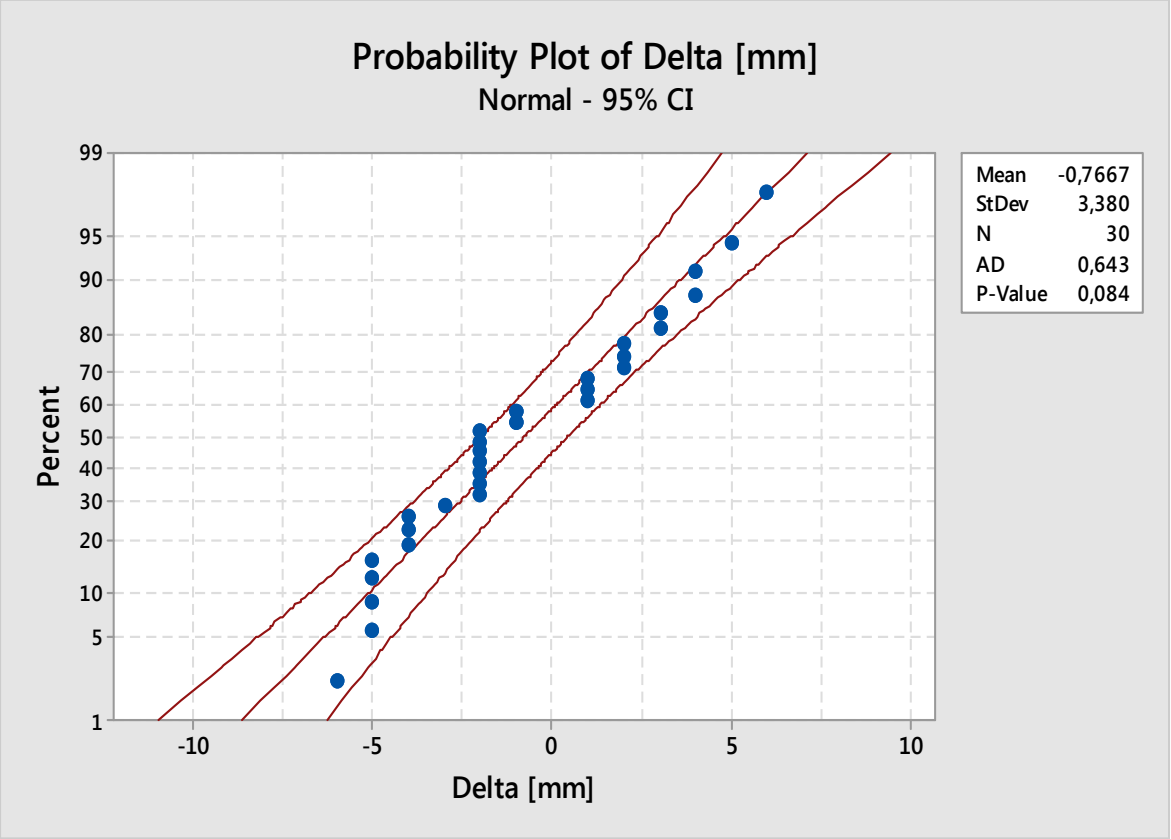


Fig. 4. The normal probability plot for the error (delta)

7. Probability Plot of Absolute Delta

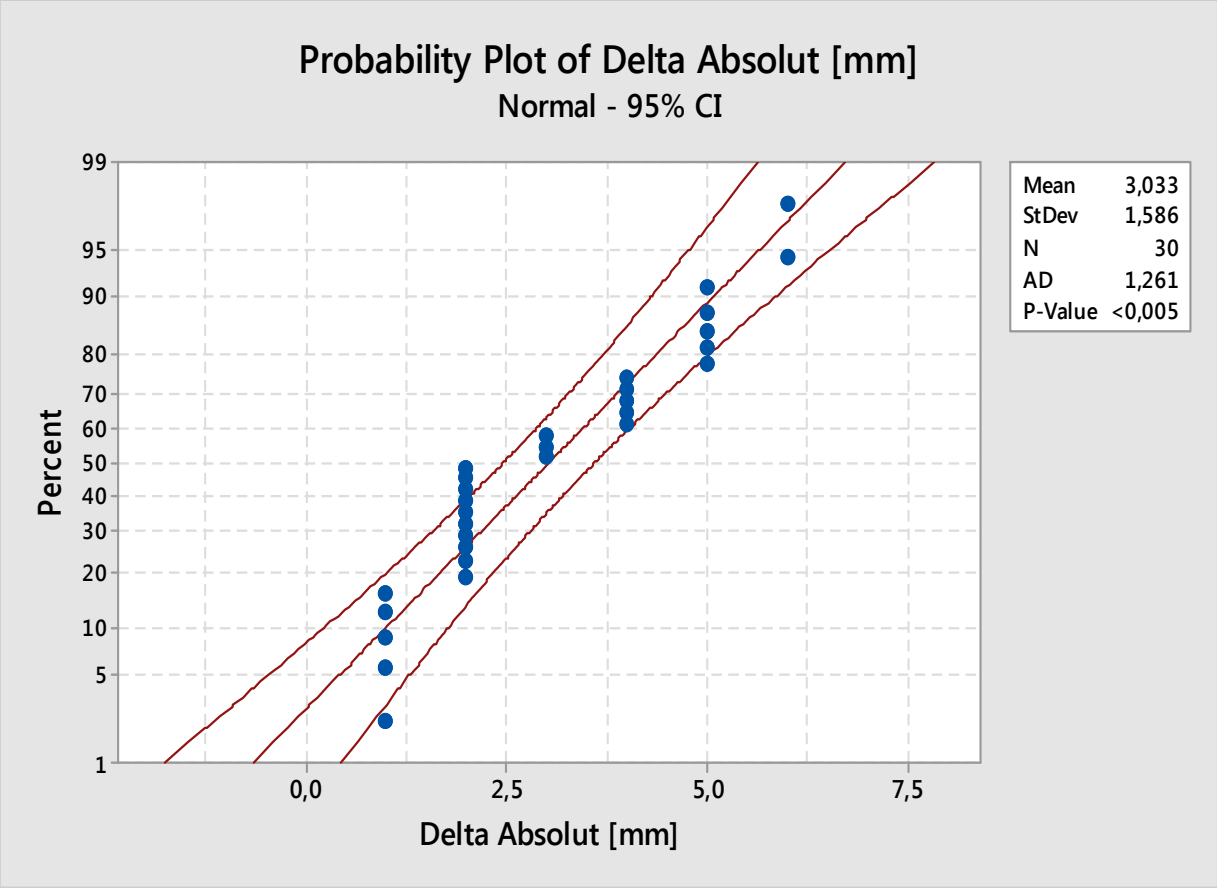


Fig. 5. The normal probability plot for the absolute error (absolute delta)

8. Fitted Line Plot

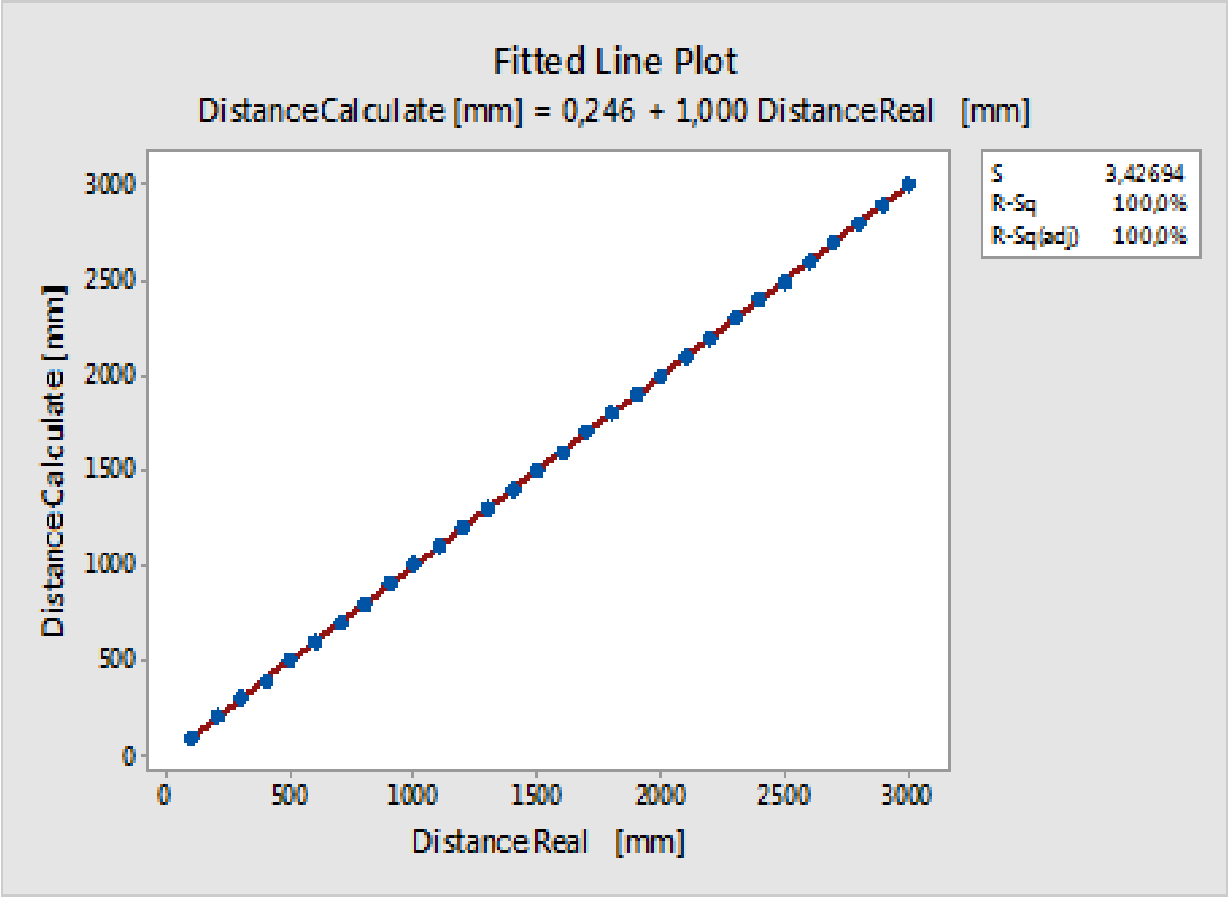


Fig. 6. Regression analysis for actual real distance and the distance computed by the system using cameras

9. Equation

$$computed\ distance[mm] = 0.246 + real\ distance\ [mm]$$

or (1)

$$Y = 0.246 + X$$

10. Residual Plots

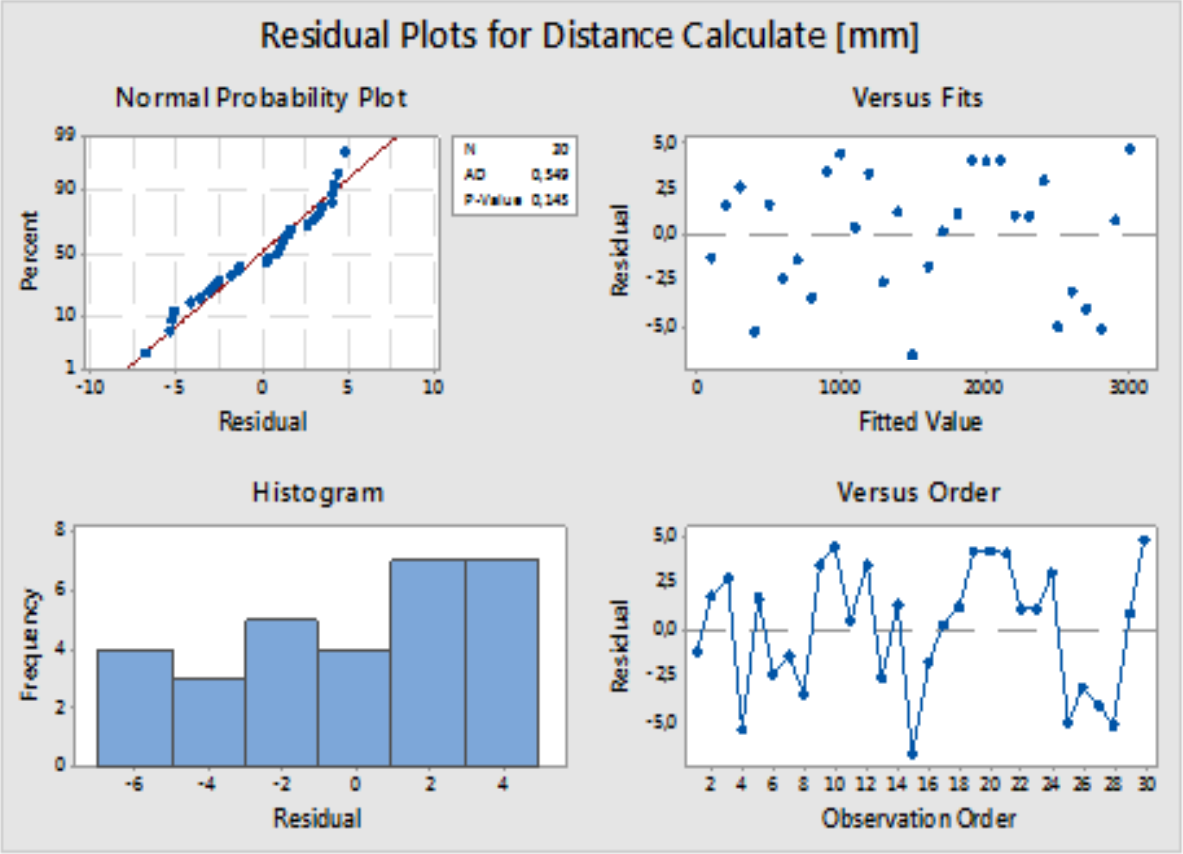


Fig. 7. Analysis of the residual values for the distance computed by the system using cameras

11. Regression Diagnostic Report

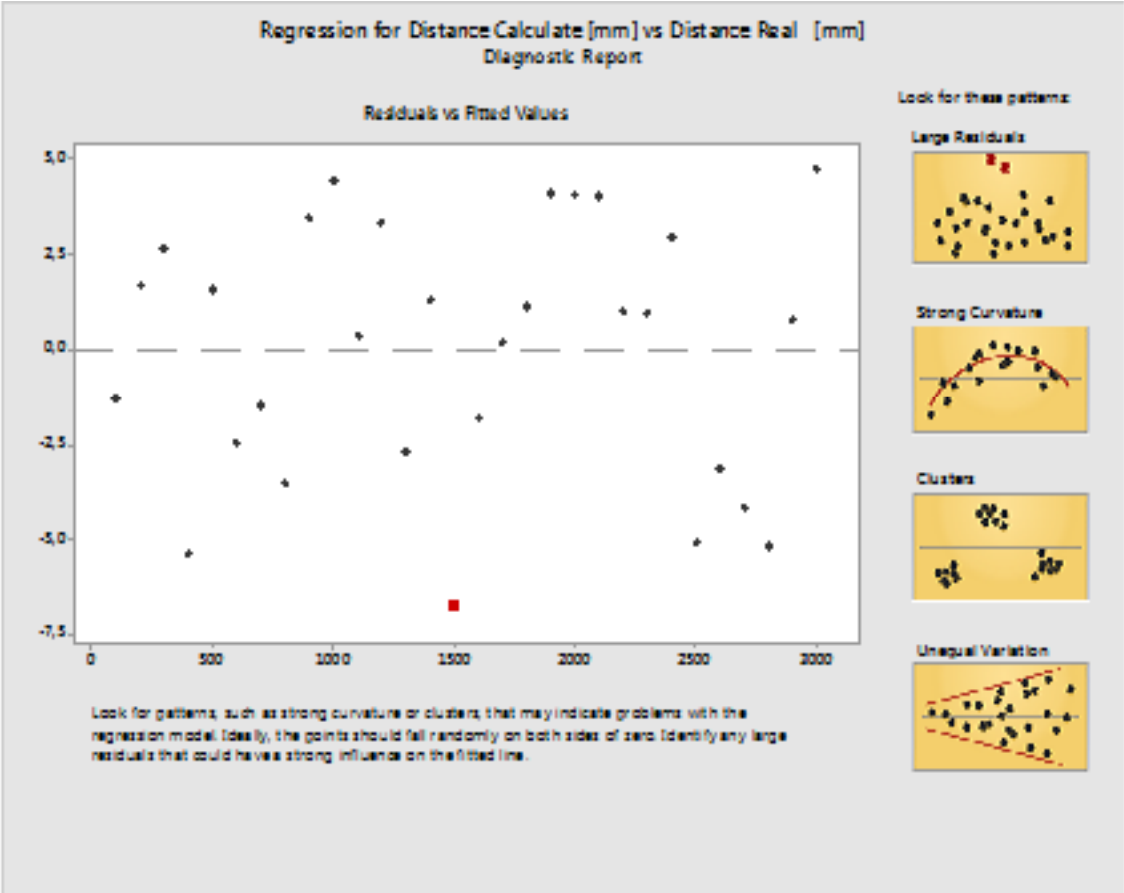
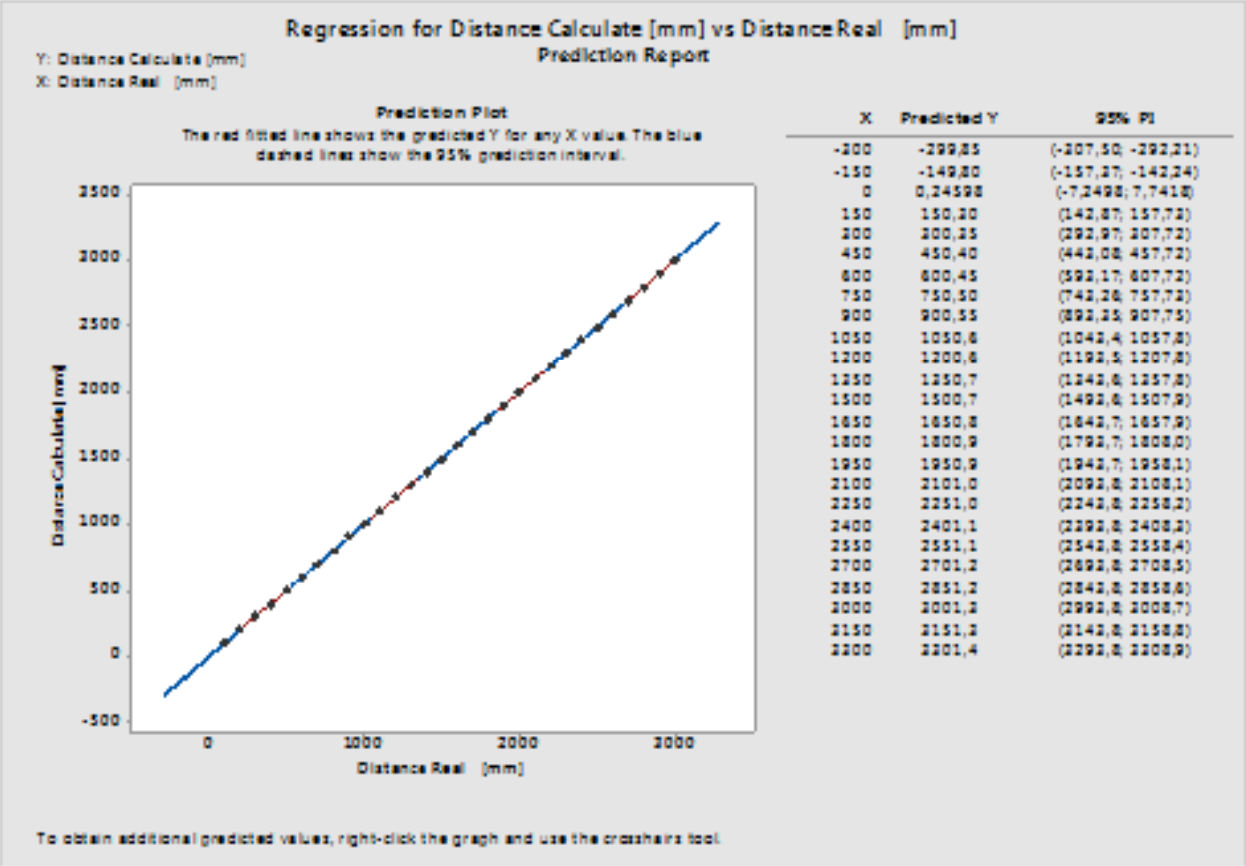


Fig. 8. The graph of residuals versus fitted values for the actual real distance and the distance computed by the system using cameras

12. Regression Prediction Report



X	Predicted Y	95% PI
-200	-299,85	(-307,50; -292,21)
-150	-149,80	(-157,37; -142,24)
0	0,24598	(-7,2498; 7,7418)
150	150,20	(142,67; 157,72)
200	200,25	(292,97; 207,72)
450	450,40	(442,08; 457,72)
600	600,45	(592,17; 607,72)
750	750,50	(742,26; 757,72)
900	900,55	(892,35; 907,75)
1050	1050,6	(1043,4; 1057,8)
1200	1200,6	(1193,5; 1207,8)
1350	1350,7	(1343,6; 1357,8)
1500	1500,7	(1493,6; 1507,9)
1650	1650,8	(1643,7; 1657,9)
1800	1800,9	(1793,7; 1808,0)
1950	1950,9	(1943,7; 1958,1)
2100	2101,0	(2093,8; 2108,1)
2250	2251,0	(2243,8; 2258,2)
2400	2401,1	(2393,8; 2408,3)
2550	2551,1	(2543,8; 2558,4)
2700	2701,2	(2693,8; 2708,5)
2850	2851,2	(2843,8; 2858,6)
3000	3001,3	(2993,8; 3008,7)
3150	3151,3	(3143,8; 3158,8)
3300	3301,4	(3293,8; 3308,9)

Fig. 9. The prediction plot for the actual real distance and the distance computed by the system using cameras

13. Regression for Model Selection

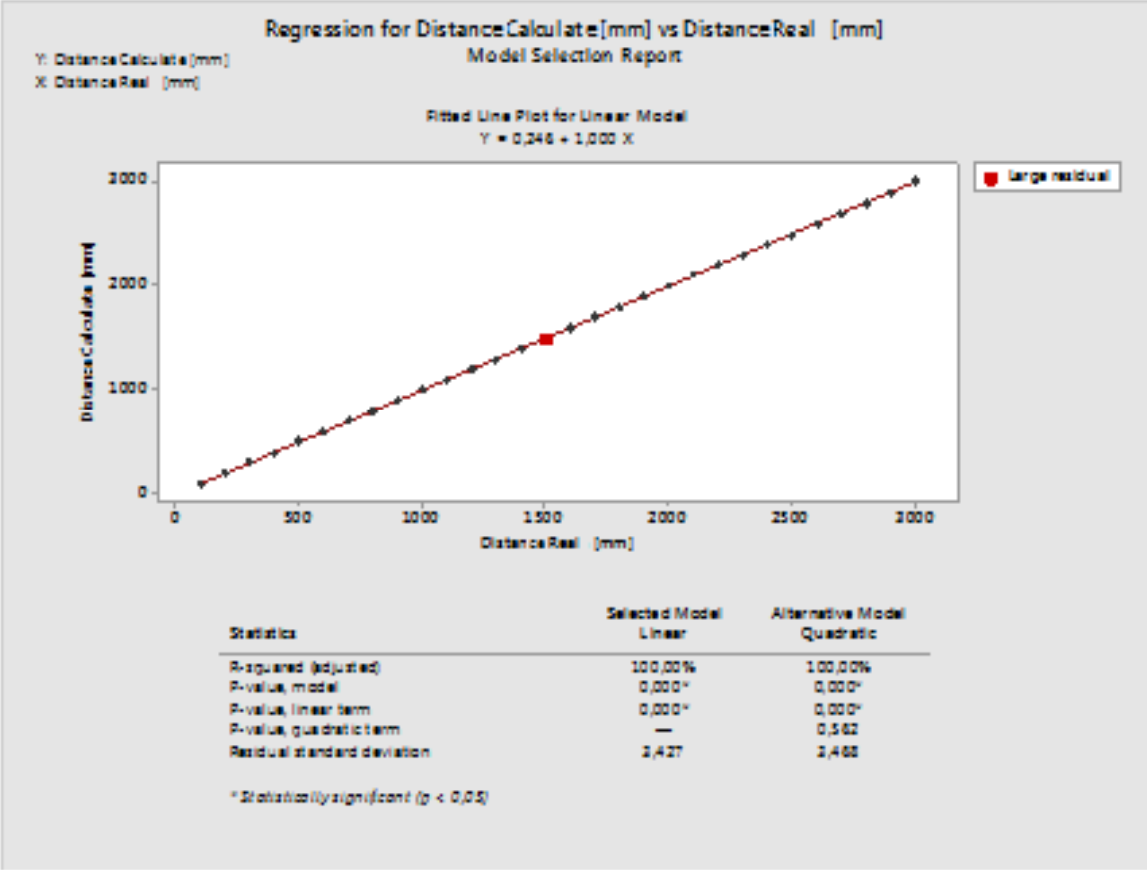


Fig. 10. The fitted line plot for linear model for the actual real distance and the distance computed by the system using cameras

14. Regression Summary Report

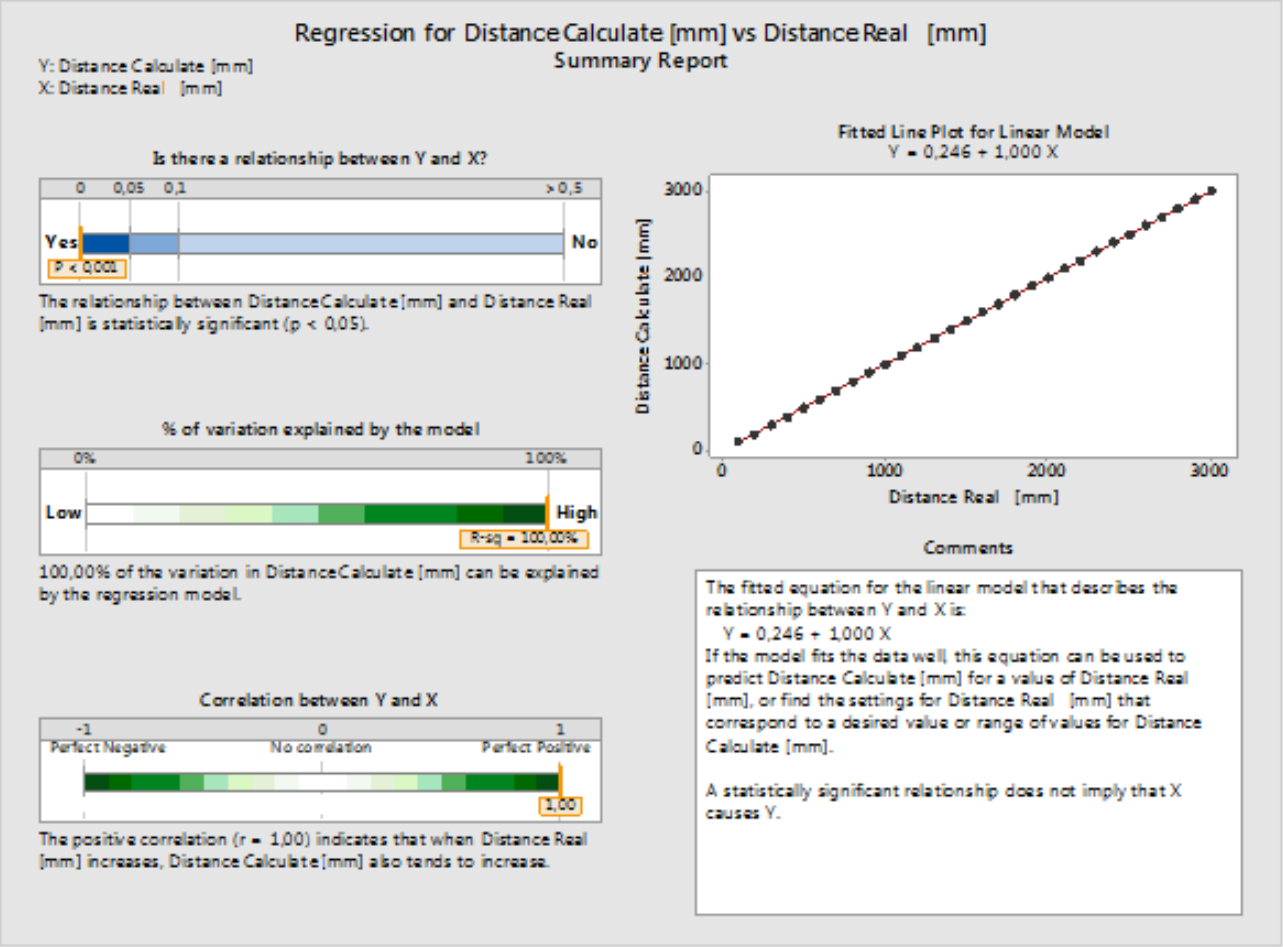


Fig. 11. Summary report of the regression analysis for the actual real distance and the distance computed by the system using cameras

15. Process Capability Report

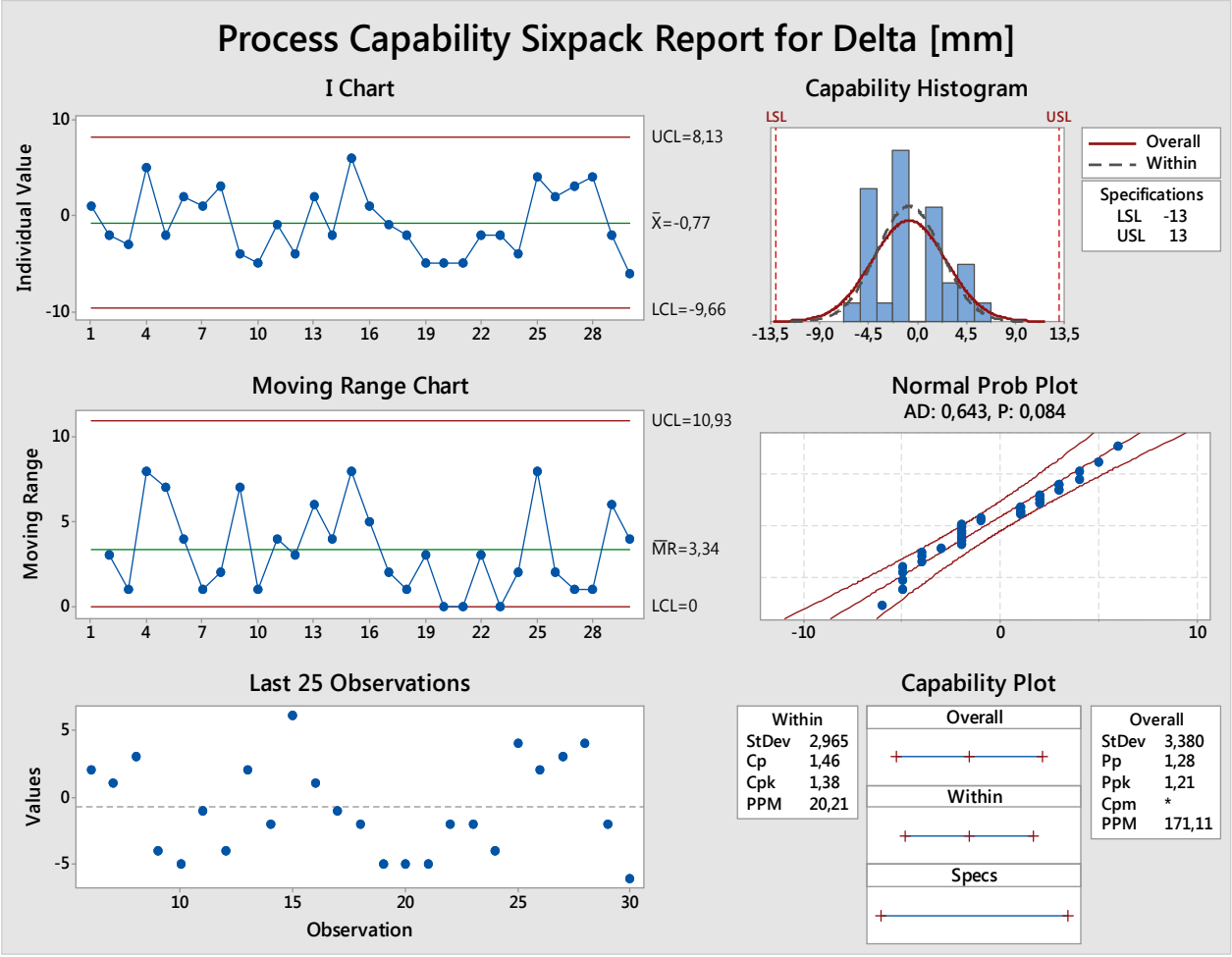


Fig. 12. The process capability analysis for the error (delta)

16. Capability Performance

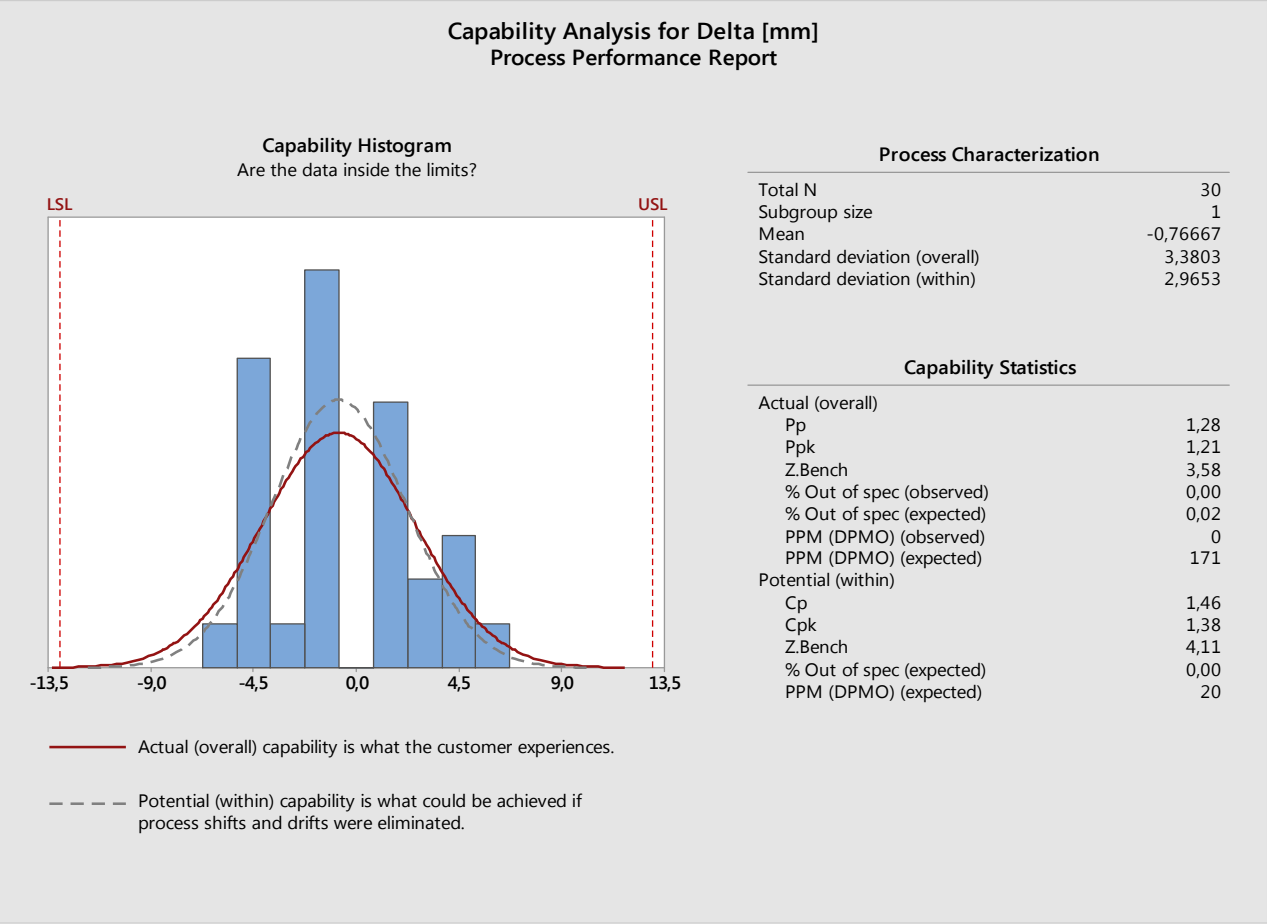


Fig. 13. The capability histogram for the error (delta)

17. Capability Diagnostic

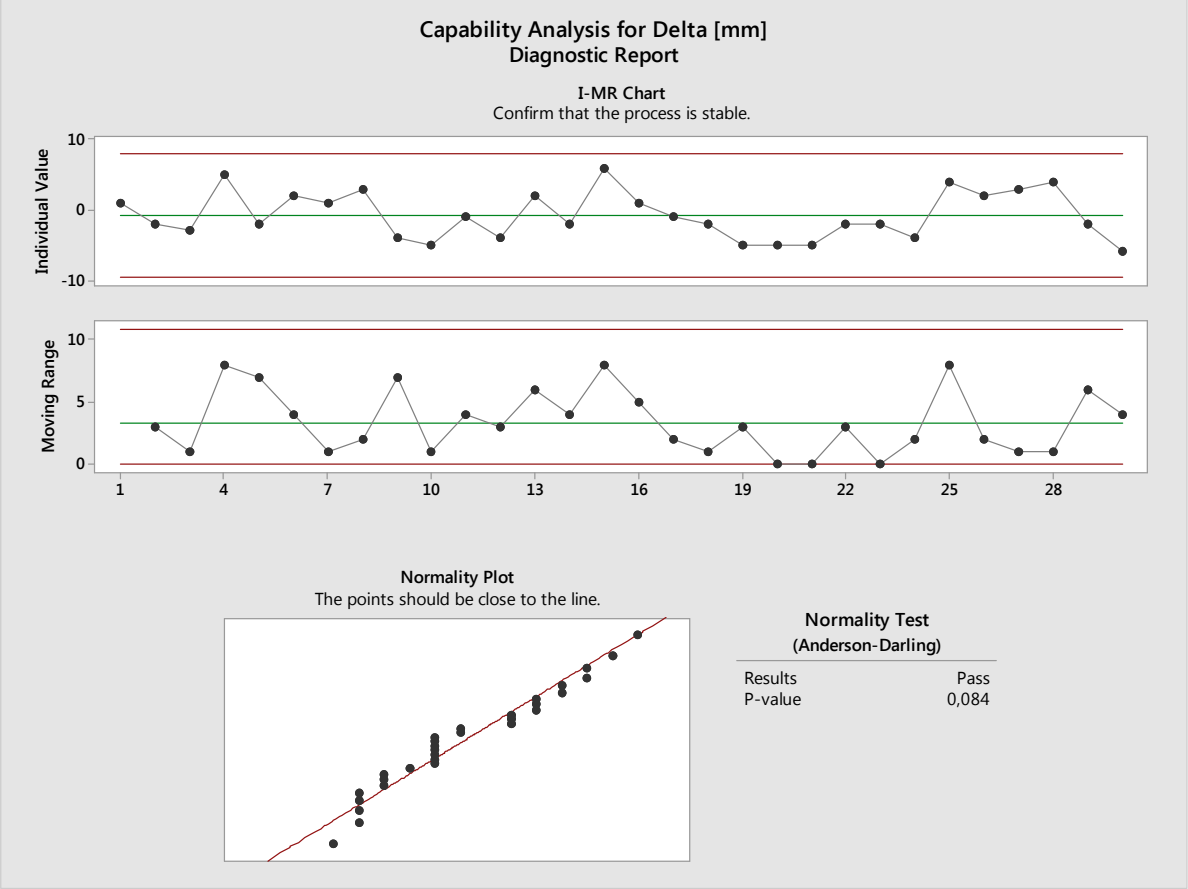


Fig. 14. The I-MR (individual value - moving range) analysis and the normality test for the error (delta)

18. Capability Summary Report

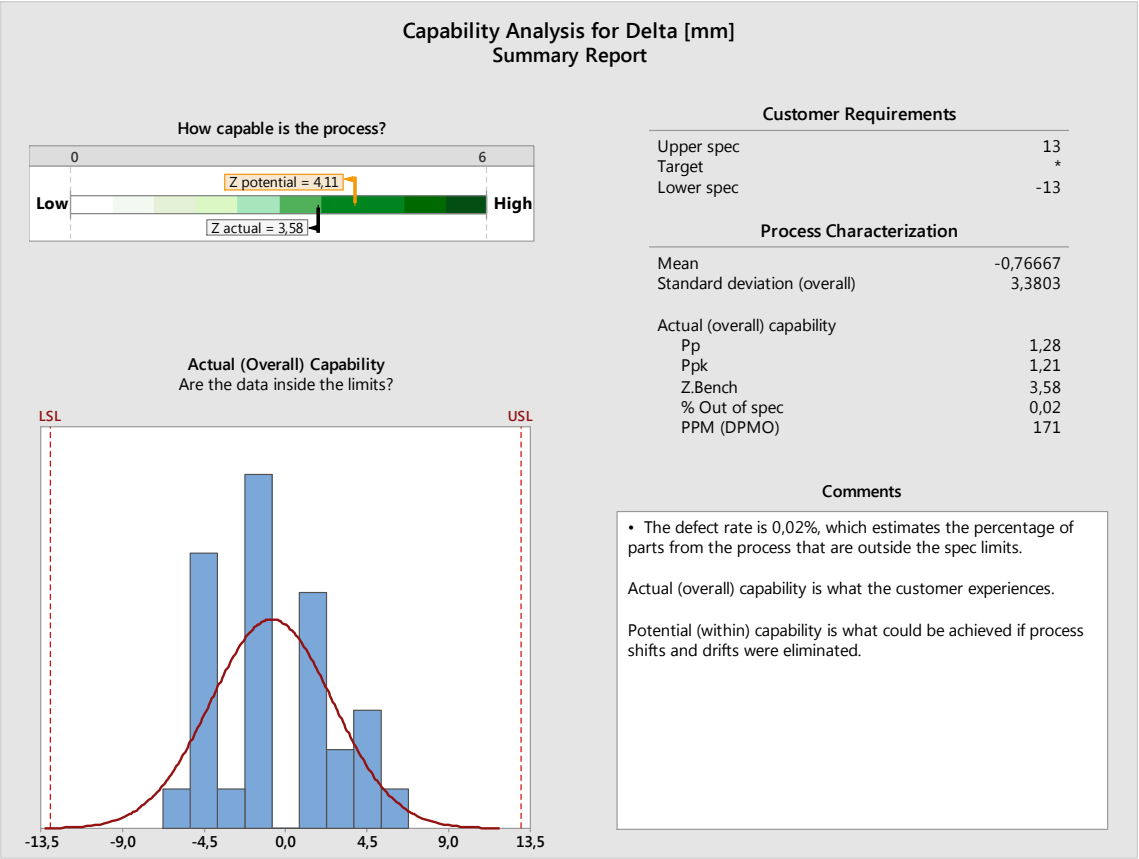


Fig. 15. Summary report of capability analysis for the error (delta)

19. Real Distance and Delta

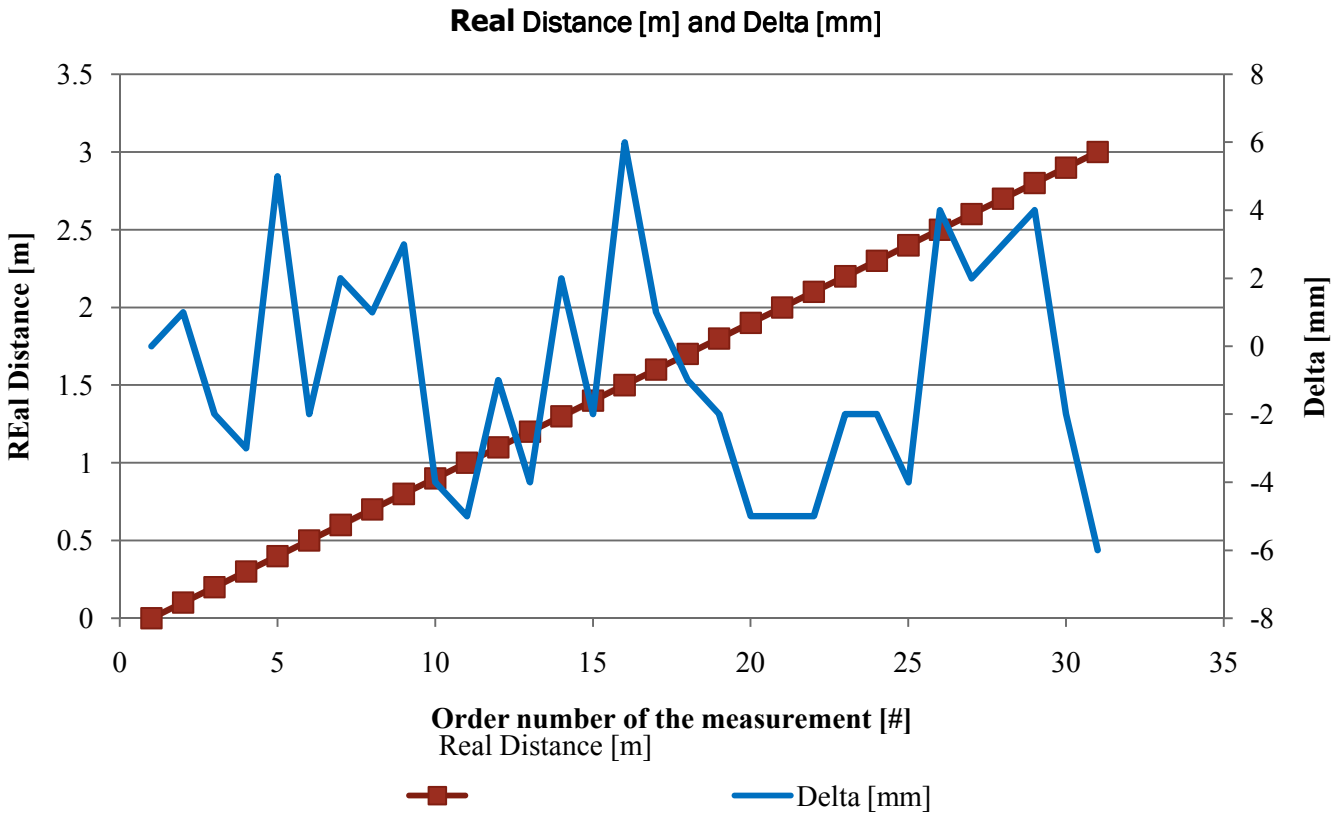


Fig. 16. Graphic representation of the actual real distance [m], and the error of measurement (delta) [mm]

20. Conclusion (1)

- As it was seen the optical distance measurement system for robotic arms was evaluated using Six Sigma tools.
- The six Sigma tools materialized by the graphs in Minitab showed that the optical distance measurement with video cameras is accurate enough and there is no need for fine tuning or replacing with other distance measurement method.
- This means that the MSA (Measurement System Analysis) has good results, 4σ accuracy which for real process is very good (6σ is the theoretical ideal process, not existent in real life).

20. Conclusion (2)

- Knowing that the MSA had good results it can be said that the industrial robots can precisely detect is position in space and the distance to the manipulated object just by using optical distance measurement using video cameras.

Acknowledgment

- This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS/CCCDI - UEFISCDI, project number PN-III-P2-2.1-PED-2016-0074, within PNCDI III.

- Visit site: tess.upt.ro

Selected References (1)

[1] Wong Guan Hao, Yap Yee Leck, Lim Chot Hun, "6-DOF PC-Based Robotic Arm (PC-ROBOARM) with efficient trajectory planning and speed control," in *Proc. 4th International Conference On Mechatronics*, Kuala Lumpur, Malaysia, May 17–19, 2011, pp. 1–7.

[2] Woosung Yang, Ji-Hun Bae, Yonghwan Oh, Nak Young Chong, Bum-Jae You, Sang-Rok Oh, "CPG based self-adapting multi-DOF robotic arm control," in *Proc. International Conference on International Conference on Intelligent Robots and Systems*, Taipei, Taiwan, October 18–22, 2010, pp. 4236–4243.

[3] E. Oyama, T. Maeda, J. Q. Gan, E. M. Rosales, K. F. MacDorman, S. Tachi, A. Agah, "Inverse kinematics learning for robotic arms with fewer degrees of freedom by modular neural network systems," in *Proc. International Conference on International Conference on Intelligent Robots and Systems*, August 2–6, 2005, pp. 1791–1798.

[4] N. Ahuja, U. S. Banerjee, V. A. Darbhe, T. N. Mapara, A. D. Matkar, R.K. Nirmal, S. Balagopalan, "Computer controlled robotic arm," in *Proc. 16th IEEE Symposium on Computer-Based Medical Systems*, New York, NY, USA, June 26–27, 2003, pp. 361–366.

[5] M. H. Liyanage, N. Krouglicof, R. Gosine, "Design and control of a high performance SCARA type robotic arm with rotary hydraulic actuators," in *Proc. Canadian Conference on Electrical and Computer Engineering*, St. John's, NL, USA, May 3–6, 2009, pp. 827–832.

[6] M. Mariappan, T. Ganesan, M. Iftikhar, V. Ramu, B. Khoo, "A design methodology of a flexible robotic arm vision system for OTOROB," in *Proc. 2nd International Conference on Mechanical and Electrical Technology*, Singapore, September 10–12, 2010, pp. 161–164.

Selected References (2)

[7] Guo-Shing Huang, Xi-Sheng Chen, Chung-Liang Chang, "Development of dual robotic arm system based on binocular vision," in *Proc. International Automatic Control Conference*, Nantou, Taiwan, December 2–4, 2013, pp. 97–102.

[8] N. C. Orger, T. B. Karyot, "A symmetrical robotic arm design approach with stereo-vision ability for CubeSats," in *Proc. 6th International Conference on Recent Advances in Space Technologies*, Istanbul, Turkey, June 12–14, 2013, pp. 961–965.

[9] F. Medina, B. Nono, H. Banda, A. Rosales, "Classification of Solid Objects with Defined Shapes Using Stereoscopic Vision and a Robotic Arm," in *Proc. Andean Region International Conference*, Cuenca, Spain, 2012, pp. 226.

[10] M. Puheim, M. Bundzel, L. Madarasz, "Forward control of robotic arm using the information from stereo-vision tracking system," in *Proc. 14th International Symposium on Computational Intelligence and Informatics*, Budapest, Hungary, November 19–21, 2013, pp. 57–62.

[11] T. P. Cabre, M. T. Cairol, D. F. Calafell, M. T. Ribes, J. P. Roca, "Project-Based Learning Example: Controlling an Educational Robotic Arm With Computer Vision," IEEE Revista Iberoamericana de Tecnologias del Aprendizaje, vol. 8, issue 3, 2013, pp. 135–142.

[12] G. S. Gupta, S. C. Mukhopadhyay, M. Finnie, "WiFi-based control of a robotic arm with remote vision," in *Proc. IEEE Instrumentation and Measurement Technology Conference*, Singapore, May 5–7, 2009, pp. 557–562.

Thank you for you attention !