Defect detection of Railway switch using 3D scanning

Maryam Ebadi[1]

Mohammad S. Lajevardi[2]

Badria Haas[3]

Morteza Bagheri[4]

The Name of Company: Hadaf

Abstract—**Purpose of this paper is to conduct a feasibility study to examine the defects in switch rails using 3-dimensional scanning. The switch defect detection tools are rare and expensive. 3-dimensional scans of a fabric and a damaged switch have been taken by the Xbox Kinect device. Since the boundary condition in each switch blade is different, image processing algorithms should start with noise reduction and then finding the damage location comparing the fabric and the damaged sample. Besides, failure mode and effects analysis approach have been used for risk analysis. With this method, maintenance priority for each switch can be determined. As a result, risk priority number calculated for maintenance management, depend on the reliability of each equipment. The proposed defect detection method with Xbox Kinect camera can lead to a more efficient resource planning and can optimize current maintenance management systems. Moreover, failure forecasting related to local condition is possible.**

Keywords—maintenance management, switch physical error, 3D scan, damage detection, risk analysis, FMEA method

I. Introduction

Maintenance Management can be considered one of the most important segments of the railway network. Often, we see casualties and financial costs of even small accidents in this important industry.

Using appropriate methods of damage detection provides facilities to find damages not only enables event prediction and develops maintenance optimization but also ensures the reliability of the system and provides safety for passengers.

In the following, feasibility of a new method to diagnose and detect physical damages of splits by analyzing 3D scans done by Xbox Kinect device will be investigated.

II. Methodology

As mentioned before, according to statistical data regarding derailment events, switches are one of the parlous points in railway network. Reducing the time detecting damages and predicting derailments is useful for maintenance optimization. Some problems in the process of traditional inspection methods, such as providing safety environment affects the inspection accuracy. 3D scanning with Kinect could replace visual inspections and increase efficiency. Efficiency of the suggested method is restricted by the switch damage detection and the cost of 3D scanner's equipment procurement, maintenance and operation services are high.

In order to detect the physical damages of rail and switch profile, Kinect connects to the power supply and Skanect (3D scanning software) in laptop and turns around the rail in 360 degree and shines its infrared, CMOS and RGB rays to the object. Synchronous with data gathering, Skanect builds the 3D model of the object. At the end Skanect gives a complete 3D model of the rail and switch profile with details.

For testing this method, an undamaged and a damaged UIC60 switch blade with radius 300 were scanned by Kinect camera. The undamaged UIC60 switch blade with radius 300 while scanning with Kinect device is shown in figure 1 and the final 3D model of the undamaged switch blade is shown in figure 2 & 3 and the final 3D model of the damaged switch blade is shown in figure 4 & 5.

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[1] *School of Railway Engineering , Iran University of Science & Technology, Tehran, Iran*

[2] *Department of Civil Engineering, University of Minho, Portugal*

[3] B. SC. Civil Engineering, University of Stuttgart, Stuttgart, Germany

[4] *School of Railway Engineering , Iran University of Science & Technology, Tehran, Iran, Morteza.Bagheri@iust.ac.ir*

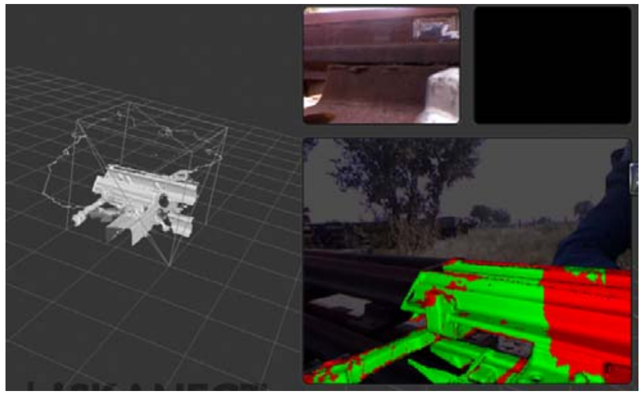

Fig. 1. Undamaged UIC60 switch blade with radius 300 while scanning with Kinect device

Fig. 2. *Undamaged UIC60 switch blade in 300 radius 3Dmodel scanning by Kinect device*

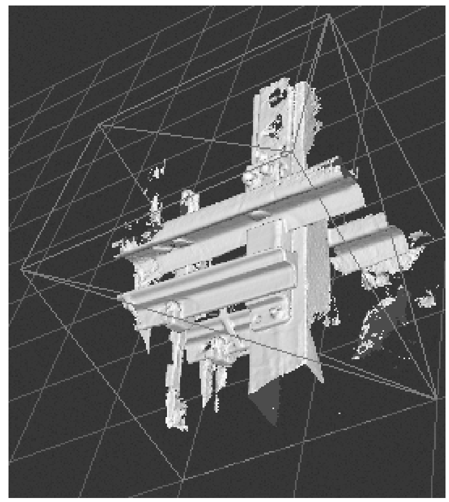

Fig. 3. *Undamaged UIC60 switch blade in 300 radius 3Dmodel scanning by Kinect device*

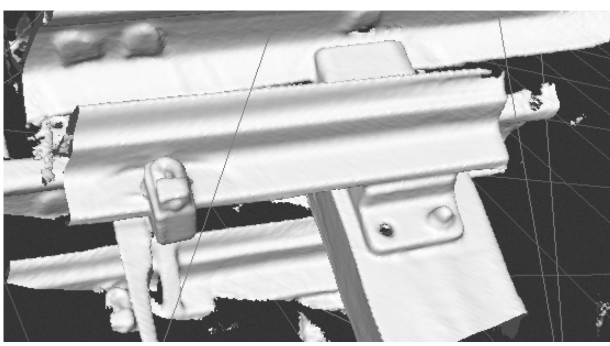

Fig. 4. *Damaged UIC60 switch blade in 300 radius 3Dmodel scanning by Kinect device*

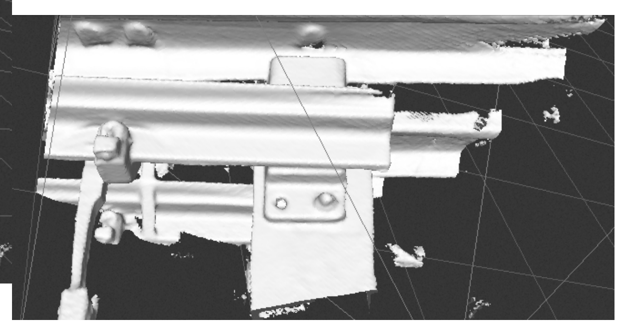

Fig. 5. Damaged UIC60 switch blade in 300 radius 3Dmodel scanning by Kinect device

In order to feasibility study of physical identification irregularities and displaying damages on two main samples the coordinate of the points located on the edge of the both undamaged and damaged switches were given. Figure 6 shows the damaged switch blade that is networked for determining the damage location.

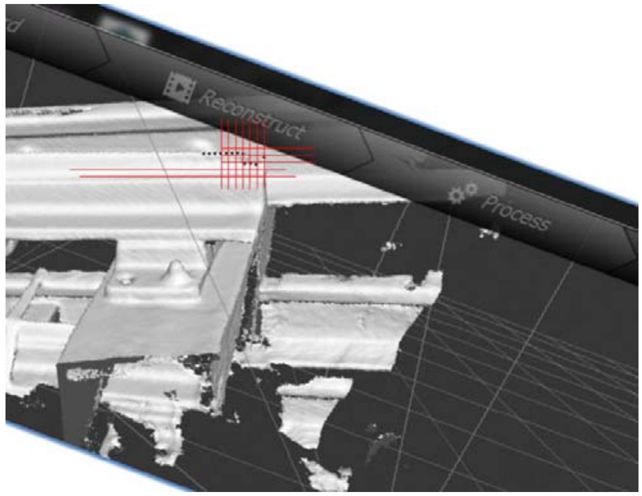

Fig. 6. *Coordinates packed of damaged switch blade*

Coordinate points along the edge of the blade were obtained as shown in table 1, and you can see the difference between the coordinates along the edge of the undamaged and damaged blade.

TABLE I. COORDINATE OF UNDAMAGED AND DAMAGED SWITCH BLADES POINTS

Fabric switch grid		Damaged switch grid	
Y	X	Y	X
15	0	14	0
16	-5	8	-5
16	-10	9	-10
17	-15	9	-15
17	-20	17	-20
17	-25	17	-25

III. CONCLUSION

The target of this research was finding a suitable alternative with more accuracy and less error in the physical damage detection than the visual inspection. According to the accomplished analysis, the feasibility study of this subject was positive. The accuracy of the 3D scanned models by the Kinect was acceptable and can be approved by investigating further 3D scans of more samples. Also, the physical damage detection was possible as well and particular damage detected. Regarding the accuracy of the proposed method, by avoiding human interference in fault perception, this method is an appropriate alternative to visual inspection methods.

Since data derived by images, pixels should change with the distance. Therefore, data was changed dimensionless with a statistical normalized system and the RPN was calculated. Specifications of 4 damaged switches have been calculated and Risk analysis with reliability indices, derived by this data with FMEA method is shown in table 2.

The values obtained from risk analysis with this method, as calculated in the risk analysis table, show the risk priority on the tip and the first part of the switch blade. Reliability of the tip of the switch blade and its first part was so low, thus this part of the switch blade must be observed and inspected continuously.

According to the results, risk assessment in the operation components of the railway network, such as the switch, can be performed with new damage detection systems such as 3D scanning.

TABLE II. RISK ANALYSIS IN FMEA METHOD

Reliability	RPN	Detectability	Occurrence Calculation		Severity Calculation		
			probability of occurrence	number of occurrence	severity	total y	x
0.162	837.320	10	10	4	8.373	35	0
0.282	717.703	10	10	4	7.177	30	5
0.234	765.550	10	10	4	7.655	32	10
0.222	777.512	10	10	4	7.775	32.5	15
0	1000	10	10	4	10	41.8	20
0.023	976.076	10	10	4	9.760	40.8	25
0.009	990.430	10	10	4	9.904	41.4	30
0.266	733.851	10	7.5	3	9.784	40.9	35
0.605	394.736	10	7.5	3	5.263	22	40
0.605	394.736	10	7.5	3	5.263	22	45
0.605	394.736	10	7.5	3	5.263	22	50
0.572	427.033	10	7.5	3	5.693	23.8	55
0.787	212.918	10	5	2	4.258	17.8	60
0.773	226.076	10	5	2	4.521	18.9	65
0.784	215.311	10	5	2	4.306	18	70
0.790	209.330	10	5	2	4.186	17.5	75
0.772	227.272	10	5	2	4.545	19	80
0.778	221.291	10	5	2	4.425	18.5	85
0.772	227.272	10	5	2	4.545	19	90
0.766	233.253	10	5	2	4.665	19.5	95
0.766	233.253	10	5	2	4.665	19.5	100
0.763	236.842	10	5	2	4.736	19.8	105
0.773	226.076	10	5	2	4.521	18.9	110
0.767	232.057	10	5	2	4.641	19.4	115
0.772	227.272	10	5	2	4.545	19	120
0.782	217.703	10	5	2	4.354	18.2	125
0.782	217.703	10	5	2	4.354	18.2	130
0.776	223.684	10	5	2	4.473	18.7	135
0.730	269.138	10	5	2	5.382	22.5	140
0.724	275.119	10	5	2	5.502	23	145
0.7189	281.100	10	5	2	5.622	23.5	150
0.7189	281.100	10	5	2	5.622	23.5	155
0.718	281.100	10	5	2	5.622	23.5	160
0.925	74.760	10	2.5	1	2.990	12.5	165