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Augmented Reality as a Tool of Training for Data Collection on Torque Auditing

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Abstract

The objective of this research is to implement an augmented reality system focused on the training of audit torque, where a person without any knowledge of the theories and application of torque, will be able to understand, implement and audit the pair residual strength in the necessary processes in order to improve the quality of a product that has bolted joints. Today manufacturing companies and especially those that focus on the automotive, aerospace and consumer need to apply precise torque and validated to the large number of bolted connections they have in their products. For the application of torque there are several very complete theories because it is a very critical process for the final quality product. Theories of torque can become complex because they need to have a preliminary knowledge of engineering, as well as a company training to implement this. Each torque required to enter certain applied force specifications so to see if the applied torque is within these, you need to audit the residual torque. The residual torque refers to know the force which is at the junction after being screwed tight.

It was observed as a result of this experiment that the inherent difference between the performance of the torque wrench and screw connection performance in delivering the force required for efficient clamping force decreases their variability with the help of augmented reality.

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Keywords: Augmented Reality; Residual Torque; Auditing torque; Variability,;Validating Torque

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1. Introduccion

Do you know how much is the amount of bolted joints inside an automobile? And do you know what is the number of bolted joints, which need to have a specific torque for security reasons? Nobody would like to buy a new car and on his first ride and suddenly a wheel goes out or the hand drive gets out of its place at the time someone is driving. The quality of an automobile depends directly on this type of errors never happen.

When speaking of quality in a car, in large part we are talking about securing torque in bolted joints. And when referring to the torque in bolted joints can be displayed two worlds, the application of torque and auditing of the same. The application of torque refers to the time that the screw connection is tightened [1] meanwhile audit refers to validate that tightened exactly to the required specification. The importance of the audit is essential for quality assurance.

How much training do you think it takes for a person without any knowledge of torque could audit the torque in a screw connection? Probably not be surprised if I told you are days, but what if they were weeks, and what if you invested time, money and resources in training a hard working person and in only a few days of work he goes out and now you need to reuse all these resources in training a new staff.

A more serious problem that training is the error in data collection. There is a saying in the statistical environment that says "garbage in, garbage out" and this means that having wrong information is the same or worse than not having information, because the decisions taken would be based on erroneous readings. So how to collect the information is very important and is to be worn by operators very precisely, there are different sequences for each different plan of inspection or audit torque, so the operator has to learn all and do no wrong in any of them. Currently there is no Poka Yoke system for data collection but with the help of augmented reality this may be the first Poka Yoke system for auditing torque.

Augmented reality is a new technology which helps transfer knowledge in the form of images and / or videos on the actual real vision. Using augmented reality could help trainings as well as improve the torque auditing process on bolted joints and in consequence increasing the quality on the product.

1.1. Methodologies

1.1.2. Torque methodologies:

Definition of torque:

Torque is the twisting force applied to an object, in this discussion a fastener. Rotational force or Torque can be expressed in several different units of measure, i.e. Foot Pounds, Inch Pounds or Newton Meters.

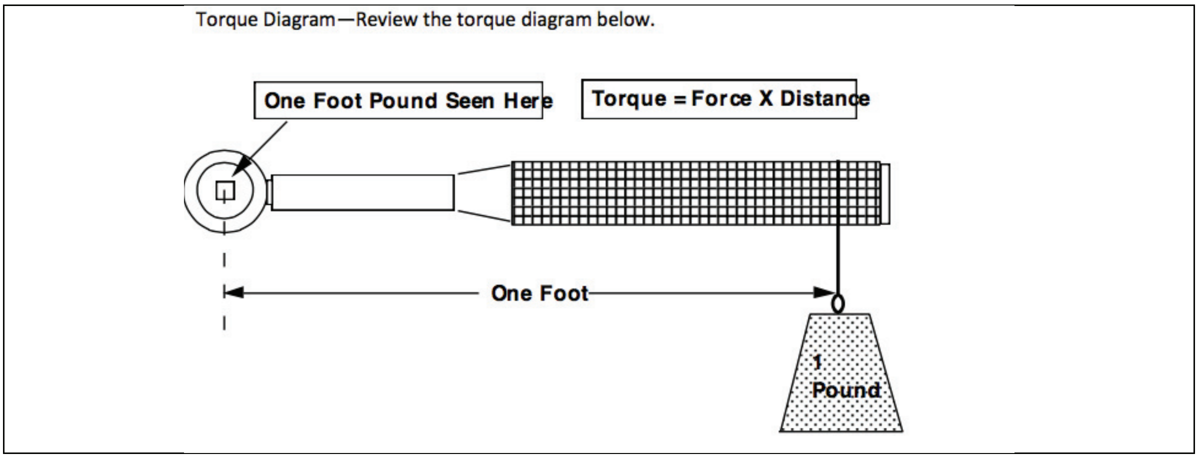

Fig. 1. Torque diagram, (Manual for Transend 3.0, Datamyte Software)

Dynamic Torque Algorithms:

The 600 Handheld Data Collectors use several different algorithms [2] (or sets of rules) to convert the transducer's analog signal to a digital value that represents the force applied. The algorithms include Restart (Angle), Torque at Angle, Breakaway, Restart (Time), Peak and Set Torque. Note: Peak being the Ford convention.

1.1.3. Augmented Reality methodology:

The technology of Augmented Reality is to create a digital animation and with the help of a camera and a wearables [3] or a device show an animation updated to the reality.

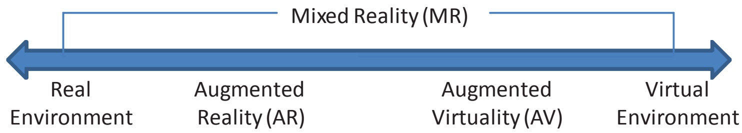

Fig. 2. Miligram-Virtuality Continuum [4]

1.2. Technologies. Equipment and devices.

The equipment to be used to achieve this experiment are as follows:

1.2.1. Torque auditing technology:

- Wrench torque auditing of 90Nm from Datamyte Company.
- 600 Datamyte handled Data Collector for data collection of wrench torque
- Transend 3.0 of Datamyte Software for programming the 600 handled Data Collector
- Example of device with bolted joints.

1.2.2. Augmented Reality technology:

- Tablet iPad 3.0 de Apple Inc.
- Unity Software for programming Augmented Reality applications.
- Autodesk Maya 2015 Software for modeling Augmented Reality animation.

Fig. 3. (a) Apple tablet; (b) Wrench torque auditing; (c) 600 Datamyte handled Data Collector; (d) Autodesk Maya 2015 Software; (e) Unity Software; (f) Experiment simulator.

2. Hypothesis

In this experiment it will be shown how the augmented reality will reduce the human errors on the actual process of auditing bolted joints and in consequence decreasing the costs of having a bad quality product.

3. Methodological frame

3.1. Methodology

Table 1. Actual process vs Process with Augmented Reality Technology

	Actual Process	Time	Process with Augmented Reality
	The actual process of torque auditing is the follow:		The process with augmented reality would be as follow:
8 hrs.	1. Training the inspector on torque	10 min	1. The inspector needs to define the bolted
	methodologies, torque auditing, the use of		joints to audit.
	handled data collector and the use of wrench	3 min.	*2. Initiate Augmented Reality application to*
	torque.		*learn the types of bolted joint.*
30 min	2. The inspector need to define the bolted joints	5 min.	*3. Start a small test on the AR app.*
	to audit.	10 min	4. Visualize the materials of the joint.
10 min	3. Visualize the materials of the joint.	1 hr.	5. Define the sequence of auditing the different
1 hr.	4. Define the sequence of auditing the different		fasteners if there is more than one.
	fasteners if there is more than one.	5 min	*6. Start a small test on the AR app to learn what*
30 min	5. Define the torque algorithm to use on each		*type of algorithm use on the bolted joints*
	joint.	30 min	7. Define the torque algorithm to use on each
10 min	6. Define the measure specifications of each		joint.
	joint.	10 min	8. Define the measure specifications of each
10 min.	7. Create the auditing program in a PC.		joint.
10 sec.	8. Transfer the program form the PC to the	5 min	*9. Start instructions on AR app for creating a new*
	handled Data Collector.		*auditing program on the right PC software*
5 sec.	9. Select the right type of torque wrench		10. Create the auditing program in a PC.
	depending on the measurement of the joint	10 min	11. Transfer the program form the PC to the
-	10. Go to the first bolted joint to get the measure	10 sec	handled Data Collector.
10 sec.	11. Stand in the right position to take the		*12. Start instructions on AR app to get the*
5 sec.	measure	2 min	*instructions to use the handled Data Collector.*
	12. Get the wrench torque in right position to		*13. Start instructions on AR app to get the right*
2 sec.	take the measure	2 min	*positions to take the measures with the*
	13. Take the measure of residual torque of the		*wrench torque.*
-	bolted joint.		14. Select the right type of torque wrench
	14. Go to the next bolted joint in the program to	5 sec.	depending on the measurement of the joint
-	take the measure.		15. Go to the first bolted joint to get the measure
	15. Finish the program after all measures are	-	16. Stand in the right position to take the
	done.	10 sec.	measure
		5 sec.	17. Get the wrench torque in right position to
			take the measure
		2 sec.	18. Take the measure of residual torque of the
			bolted joint.
		-	19. Go to the next bolted joint in the program to
			take the measure.
		-	20. Finish the program after all measures are
			done.
Total. 10 hrs. 30 min 32 sec.	Total. 15 steps.	Total. 2 hrs. 32 min. 37 sec.	Total. 20 steps.

3.2. Sample

For the propose of this experiment it was selected 20 inspectors of which 10 of them are experts on torque applications and 10 of them know nothing about torque. And they are going to make 5 samples each one of them.

The data to recollect is to know how many errors each expert inspector obtain in the actual process and on the other hand how many errors get each inspector, who knows nothing about the subject, in the same process with augmented reality technology.

3.3. Data Analysis

Table 2. Average of 10 inspectors and 5 samples each one in the process of auditing torque without Augmented Reality technology.

Human errors without Augmented Reality	
	Average
Inspector 1	5
Inspector 2	6.2
Inspector 3	6.6
Inspector 4	6.8
Inspector 5	7.4
Inspector 6	8.8
Inspector 7	6.8
Inspector 8	6.4
Inspector 9	5.8
Inspector 10	9.0

Table 3. Average of 10 inspectors and 5 samples each one in the process of auditing torque with Augmented Reality technology.

Human errors with Augmented Reality	
	Average
Inspector 1	1
Inspector 2	2.0
Inspector 3	1.2
Inspector 4	1.2
Inspector 5	1.6
Inspector 6	2.2
Inspector 7	1.6
Inspector 8	1.6
Inspector 9	2.4
Inspector 10	1.6

After the data was obtained we could get the standard deviation of the different process and are the follows:

- Actual process:
  StDev = 1.24

- Process with Augmented Reality:
  StDev = .045

3.4. Results

The t-student [5] experiment has the follow results

Test t(student)	$\|t_0\|$	T(10,0.05)	$H_0: \overline{X}_1 = \overline{X}_2$	$H_1: \overline{X}_1 \neq \overline{X}_2$
Average errors with AR vs without AR.	12.52	0.00	Rejected	Approved

The h0 is rejected and now it can be said with 95% reliability the actual process is different to the process with Augmented Reality.

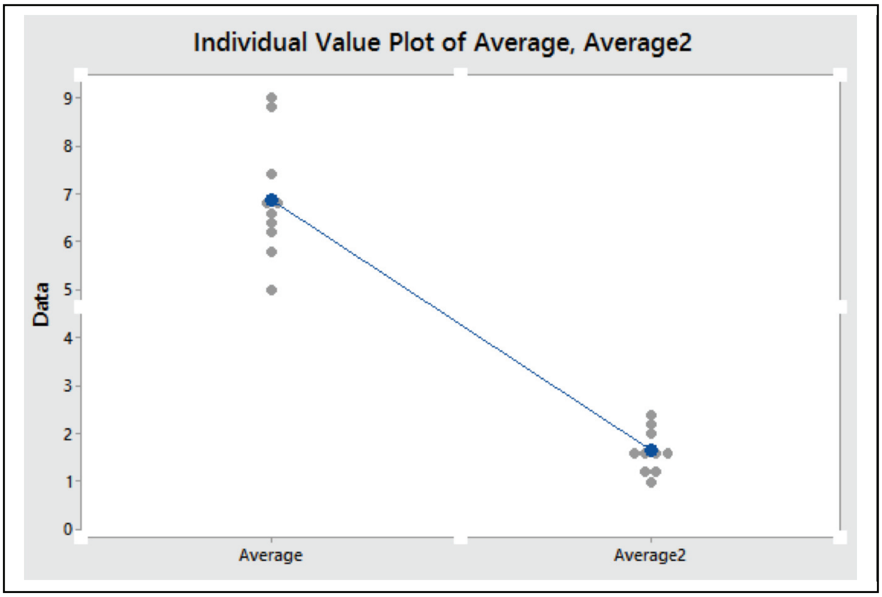

Fig. 4. Graphic of Minitab showing the Average of errors on the actual process vs process with AR technology. [6]

The fig. 4 shows how the average 1, which is the actual process, shows more human errors than the average 2 which is the process with AR technology.

4. Conclusions

The torque theory can be very difficult to understand, and even more difficult to understand is the auditing torque theory without mentioning using it on daily practice. It take a lot of time in training to understand all of this theories and also to decrease the mistakes in taking measures but with the help of this experiment we could learn that the AR technology can decrease the process time and the mistakes in the auditing torque process.

At the end this experiment could be very important to the companies because the Augmented Reality technology would reduce cost in training time, in process time and more important in costs for bad quality.

5. Future work

It is interesting how the augmented reality could decrease the human errors on one specific process but it was still some errors. As future work on research and development it is create an application mixed with some type of machine to could decrease the human errors to cero, in other words it is to create a poka yoke system with augmented reality technology.

6. Acknowledgements

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References

1. Santiuste C, Barbero E, Henar Miguelez M. Computational analysis of temperature effect in composite bolted joints for aeronautical applications. *Journal of Reinforced Plastics and Composites* 2011; **30**(1): 3-11.
2. QDA Q-Management. ASI Datamyte Spec Sheet. Available on: http://www.asidatamyte.com/ftpgetfile.php?id=166. (Retrieved Oct 26, 2015)
3. Azuma RT. A survey of Augmented Reality. *Teleoperator and Virtual Environments* 1997; **6**(4):355-385
4. Milgram P, Takemura H, Utsumi A, Kishino, F. Augmented Reality: a class of displays on the reality-virtuality continuum. In Photonics for Industrial Applications. International Society for Optics and Photonics, 1995. p. 282-292.
5. Arrona F. *Black Belt Seis Sigma.* 24th ed. Monterrey: Editorial Centro de Competitividad de Clase Mundial, Facultad de Ciencias Físico – Matemáticas, Universidad Autónoma de Nuevo León; 2007.
6. Soni M. Defect Prevention: Reducing Costs and Enhancing Quality. iSixSigma. Paper online. Available on: http://www.isixsigma.com/industries/software-it/defect-prevention-reducing-costs-and-enhancing-quality/. (Retrieved Oct 26, 2015)