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Wearable Data Acquisition System for Measurement of Assessment of Repetitive Tasks Rating Of Vehicles

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Abstract-*TheAssessmentofRepetitiveTasks(ART)toolis intended to assist you in assessing the risks associated with tasks that involve repetitive upper-limb movement (arms and hands). It aids in identifying some of the most frequent risk factors for Upper Limb Disorders in repeated job environments .It is aimed and is mainly used for designing , assembling, inspecting of works that require a lot of repetitive work. It should be used with the aim of reducing the risk of any health injuries caused to the worker due to repetitive motion of a particular upper part of the body.*

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I. INTRODUCTION

SAE International's BAJA SAE (Society of Automotive Engineers) competitions are hosted all over the world. The goal of this competition is for teams to construct a four-wheel all-terrain vehicle to imitate real-world engineering design projects and obstacles. The main event of this sport is a four-hour endurance race that tests the vehicle's sustaining limits as well as the driver's tiredness. Our main goal is to design a vehicle that will last for the duration of the event without generating excessive weariness to the driver. For this reason, ART is used to check the amountof strains developed in the upper limbs of the driver during designing phase. CATIA software was used to get the requiredangles in the initial stages of the designing. Due to many limitations in software, a real time test setup was needed to measureactual ART rating of the driver for designed cockpit.

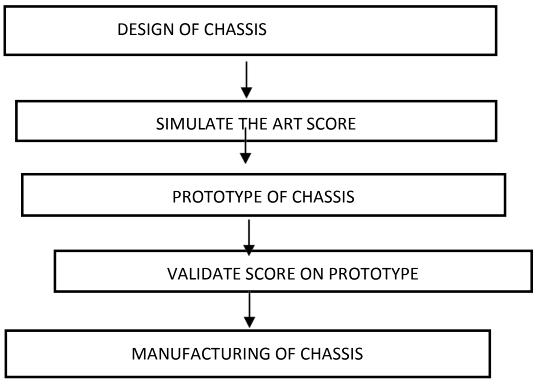

Fig.1Flow chart

II. DESIGNING

1. Designing of cockpit

The basic parameters of the driver, such as height, sitting shoulder height, buttock breadth, shoulder width, and elbow distance, are taken into consideration when designing the cockpit. After that, adequate clearances are added to these dimensions to arrive at the basic frame design. A rough chassis is created, which is assessed for several ergonomic features to ensure driver comfort, taking into account sub-system integration as well as the above driver measurements. In the beginning, CATIA software is used to calculate the angles needed for the ART calculation..

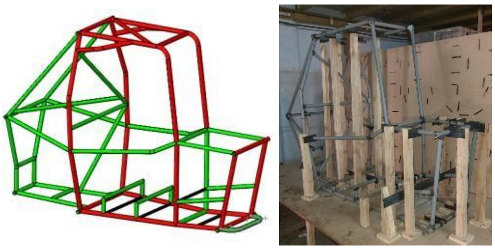

Fig.2Designedandprototypeimplementation

B.SignificanceofART

Other ergonomics tools don't take into account the task's duration, available recuperation time, or the risk of hand-arm vibration. It only permits the evaluator to analyse one employee's worst-case posture at a single point in time, hence representative postures are required.. The Need for this competition is continuous movement of upper limbs for steering the steering wheels. ART helps usin giving the range of the strain developed in the upper limbs , wrist hand considering the frequency of movement , amount of rest,basicallygivingusamoreaccurateresultsofdriverscomfortandfatiguelevel.

Thissystemcanbeusedtoanalyseforanagegroupbetween18-35andforallkindsofvehiclesaswell.

(a)CATIAsoftware **(b)Validationonprototype**

Fig.3Validation of ART score

2. Needforvalidation

During calculation of ART on software Indian manikin was not available in directory leading to improper lengths andangles of driver posture. Due to this reasons, a need for real time measurement of ART rating came into pictureconsideringall dynamic conditionsofvehicle

III. CALCULATION

ARTCalculation aregroupedinto fourstages:

L: Frequency and repetition of movementsM: Force

N: Awkward postures of the neck, back, arm, wrist andhandO:Additionalfactors, includingbreaksandduration

L1-Armmovements

observethemovementofthearmandselectthecategorythatismostappropriate.Itispossibletoselectintermediatescores. Assessboththeleft (L) andright(R) arm.

Lessfrequently	0
Frequently	3
Veryfrequently	6

L2–Repetition

This relates to arm and hand movement, but not finger movement. Count the number of times the same or a comparable pattern of motion is repeated over a certain amount of time while observing the movement of the arm and hand. Both the left (L) and right (R) arms should be evaluated.

Lessthanorequalto 10times/min	0
11-20times/min	3
Morethan20times/min	6

MForce

The level of hand force can be determined using one of two methods: Inquire with the individual conducting the work if there are any actions that involve arm, hand, or finger muscle exertion. Ask the worker to describe the level of force involved in each action if such acts are identified (eg light force, moderate force, strong force, or very strong force). Otherwise, utilise the written descriptions below to figure out how much force your hand is exerting.

Light	Withinthecomfortofuser
Moderate	• Pinchingorgripingobject • Movinglever • Movingcomponents • Forcingitems
Strong	Highforcefortheuser
Verystrong	Maximumforcethe usercanapply

	light	moderate	strong	Verystrong
Lessfrequent	0	1	6	Changeindesign
15-30% of time	0	2	9	Changeindesign
40-60% of time	0	4	12	Changeindesign
80% oftime	0	8	Changeindesign	Changeindesign

N1 neck

Nomotion/verylessmotion	0
Bendortwistfor15-30%ofthe time	1
Bend ortwistformorethan 50%of thetime	2

N2back

Closetobody/withsupport	0
Raisedforsometime	2
Raisedformorethan halfofthetime	4

N3 elbow

Neutral/nomotion	0
Anybentortwist	1
Anybentortwistformorethan halftimetheduration.	2

N4 Wristposture

Neutral/nomotion	0
Deviatedforpartofthetime	1
Anybentortwistformorethan halftimetheduration.	2

N5hand/figuregrip

Powergrip	0
Widefingergripforpartofthetime	1
Widefingergripformorethan halfofthetime	2

N1 break

Frequentbreaksforuser/lessthananhourofcontinuous work	0
1-2hoursofwork	2
2-3hoursofwork	4
3-4hoursofwork	6
4 or morehoursofwork	8

N2 Workpace

Easytokeepupwithwork	0
Moderate/Keeping up with work can be difficult at times.	1
Difficult	2

O3 otherfactors

Identify any other factors that are present in the task. Gloves, for example, alter grip and make handling more difficult; the hand/arm is exposed to vibration; the task requires fine precise movements of the hand or fingers; Assessboththeleft (L) andright(R) arm.LR

Nofactors	0
Onefactorpresent	1
Morethanonefactorspresent	2

O4Duration

Lessthan2hoursofwork	X0.5
2 -4 hoursofwork	X0.75
4-8hoursofwork	X 1
Morethan8 hoursofwork	X1.5

Final output

Calculating the task score to calculate the task score, add together the scores on the score sheet.

Task score = L1 + L2 + M + N1 + N2 + N3 + N4 + N5 + O1 + O2 + O3

If you're evaluating both arms, keep the scores for the left and right arms separate and don't add them together.

How to calculate the exposure score

It is possible to change the task score to represent the overall time a worker spends on the task. To compute the exposure score, multiply the task score by the relevant duration multiplier..

Taskscore XDuration multiplier=Exposurescore

The task and exposure scores are used to prioritise the tasks that require immediate attention and to assess the efficacy of any modifications..

0-11	low	Everythingseemsgood
12-21	Medium	Changesmayrequire/not necessary
22 or more	High	Urgentchangesrequired

...(1)

IV. DAQSYSTEMFORMEASUREMENTOFA.R.T.

There was a requirement to validate the A.R.T. score with the programme, so a DAQ system for A.R.T. score measurement was put up. As we all know, the calculations require a number of angles from the driver's body, therefore flex and gyroscope sensors were put on the driver's suit to measure these angles. The microcontroller used was an Arduino UNO, and the sensors utilised were chosen with this in mind..Because the

MPU 6050 is a 6-axis gyroscope, it was used for the trunk and shoulder angle..Weselected2.2”flexsensorsfortheelbow,wrist,andneckanglemeasurement.Laptoppowerwasusedasasourceasitgivesaconstant5Voutput.

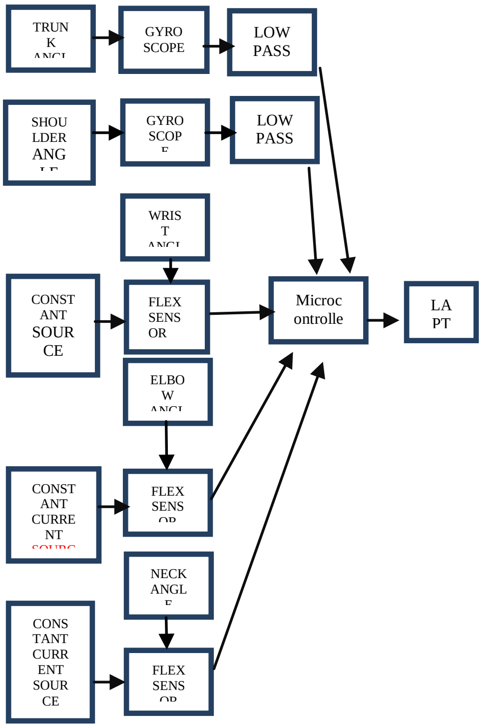

Fig.4BlockDiagramof DAQSystem

Thepositioningofthesensorsisasshownin thefigure.

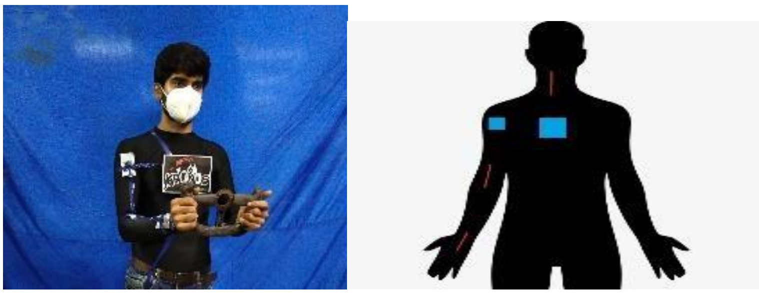

Fig.5SensorPosition
Blue:Gyroscope,Red:Flex Sensor

Two gyroscopes working on I2C protocol are used i.e. both the gyroscopes use the same data line which is SDA forArduino UNO but have a different I2C address which is done by setting the into pin high on one of the gyroscopes. We use low pass filters with a cut-off frequency of 270 Hz for signal conditioning, as well as digitally programmable low pass filters available in the MPU 6050 module, which alternate their cut-off frequency between 188 Hz and 256 Hz, ensuring noise reduction due to vibrations and other external factors. We utilise a 7805 voltage regulator IC to create a separate constant voltage supply for each gyroscope so that data is not influenced by voltage fluctuations, and we calibrated the gyroscopes using the same supply as the drivers suit. The trunk angle sensor is attached to the suit's main box on the torso.

Fig.6L:Trunkanglesensor,R:Shoulder anglesensor

For the purpose of angle measurement of wrist twist, elbow, and neck angles we use OEM Spectra symbol 2.2" flexsensors.To avoid erroneous data due to current fluctuations, we have a separate constant current source for each flex sensor. We measure the voltage using a voltage divider circuit across the flex sensor as the resistance of the flex sensor changes with change in bend angle. The constant current source current is chosen based on the flex sensor's resistance variation range as well as the microcontroller's ADC range. The Arduino UNO's ADC has a range of 0-5 V, whereas the 2.2" flex sensor has a resistance variation range of 30-70kOhm. A Wilson current mirror circuit has been built to deliver constant current to the flex sensors, the current value of which has been determined.`

TABLE II. CURRENTVALUES

FlexSensor	**CurrentValuesforconstantcurrentsource**
2.2" Spectrasymbol flex sensor	0.50mA

The wrist angle sensor has been placed on the wrist, the elbow angle, neck angle & leg angle sensor has been stuck onto theirrespective joints to provide us with the data. The mounting of the sensors has been done onto the suit by sticking with a tapeonto the driver's suit. The sensors and placement is shown in the images below. We have us Arduino Software to view therecorded angle values.

ScoresobtainedonBaja car

RIGHTSIDEOFTHE BODY		score
L	A1ARMMOVEMENT	6
	A2REPETITION	3
M	FORCE	4
N	C1 NECK POSTURE	0
	C2BACK POSTURE	0
	C3 ARMPOSTURE	2
	C4WRIST POSTURE	2
	C5HAND/GRIP	0
O	D1BREAK	2
	D2 WORKPACE	0
	D3OTHER FACTORS	0
	D4DURATION	0.75

Taskscore=6+3+4+0+0+2+2+0+2+0+0=**19**
Exposurescore=19×0.75=**14.25**

Similarly,the scorefortheleftsideisalso14.25

V. RESULTANDDISCUSSION

Considering dynamic condition of driving, driver has to continuously move wrist, arms, neck and truck which results incontinuous amount of forces onthese body parts. Taking into consideration these aspects, on testing the DAQ on our BAJAvehicle the exposure score is 14.25 which is a medium level risk, which is different from the score obtained from software(i.e., 9.75), In this calculation the worst case scenario was considered where the drive is driving for 4 hours continuouslywithout stopping for fuel refining or breakage or any such uncalled situations. As a result, we can conclude that the software simulation results cannot be blindly followed because it has many limitations, and that the results obtained must be validated, as we did for our BAJA buggy, and that these software limitations can be overcome by validating the results in real time using our DAQ system. Because ART is a universal rating that can be used for all activities, not just driving a vehicle, this wearable DAQ can be used to determine the ART score for typical everyday job activities, which can help us detect risk factors for all activities, not just driving a vehicle.

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