An attachment for monitoring of tractor rear mounted implements

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Abstract: Tractor operated implements are attached to the tractor at its rear side. Regular monitoring of these working implements working is not easy as envisaged by others who are not tractor operators. The tractor operator needs to adopt uncomfortable posture as well turns his neck backward for monitoring of the working implements which results in muscular pain and fatigue of the tractor operator. As a solution to this issue, a camera based rear mounted implement monitoring system was developed and evaluated. Drudgery reduction which form part of the performance indices was analyzed in terms of heart rate and SpO2 level. The amount of oxygen present in the operator's blood along with heart rate was measured using a pulse oximeter. The amount of SpO2 before and after monitoring the rear mounted implement was measured carefully at every 2 minute interval. While amount of SpO2 after installing rear mounted implement monitoring system was also measured and compared with the values obtained earlier. Test results of the study revealed that there was a significant difference in heart rate as well as SpO2 level measured with and without the camera monitoring system. The tractor operator feels comfortable after installing the system.

Keywords: Camera monitors system, Drudgery, Herat rate, Pulse oximeter. SpO2, Tractor, Rear view

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1 Introduction

Indirect rear side view could be obtained by means of inside and outside mirrors and inside mirror. Primary design factors which determine the working of outside mirrors are curvature, size and spatial localization. Experiment was done using plane, convex and concave mirrors. A convex mirror was found to be more effective in the area of increasing field view as compared to the use of a plane mirror of equal size (Sugiura and Kimura, 1970). Sjflot (1980) carried out an experiment on rear view mirror attached to a tractor for facilitating rear mounted implement monitoring. It was revealed that rear view mirrors made it possible to view behind the tractor without turning around and to see areas along the tractor that cannot otherwise be visible. Drudgery involved in the monitoring operation was analyzed through the heart rate monitoring.

Kourtellis et al., (2009) noted that rear crashes occurred in most of the vehicles due to lack of the driver to completely view the rear side of the vehicle. The area behind the trucks is much bigger when compared to other vehicles such as cars. In such situation the driver cannot see the rear side obstructions, person or other vehicles. It was reported that a rear view mirror is not sufficient alone to view

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the back side. It required establishing a new technology that is a camera based monitoring system (CBMS) that has good image quality so that the driver can accept the new mounted system. The use of camera monitoring system when compared to the use of traditional side view mirrors offers a lot of benefits to the driver. Position of camera fitted in the rear side of the vehicle could be changed with respect to the driver's interest. In order to get clear rear view, camera should be placed in a manner that it can display the total back side area. Lower camera position results in smaller gaps and gives higher variance in gap, while higher camera position was found to have more effects in the opposite direction (Schmidt et al., 2016).

Bernhard et al., (2021) investigated the feasibility of camera monitor systems as a kind of driving simulator. They have replaced traditional mirrors and placed rear view camera. Thirty-six drivers were performed multiple lane changes in a last safe gap paradigm. The camera position, velocity and velocity of approaching vehicle were varied according to the experiment. Results revealed that low camera position tend to decrease safety. Schkreba et al., (2021) reviewed driver perception while using a camera based digital side mirror. Fifteen drivers were randomly taken and asked to drive the vehicle. Many of the participants indicated preference for conventional mirrors. Moreover, there was no difference found in the performance accuracy or reported workload between conditions.

Most of the implements operated by farm tractors are mounted at the rear side. Monitoring of rear mounted implements has been a general practice that has been done manually by tractor operators. The tractor operator has two tasks to carry out, one is controlling the steering by looking forward and the second one is by looking backward in monitoring the working action of the rear mounted implement. Monitoring of rear mounted implement have made tractor operator to experience such an unpleasant situation that comprises of uncomfortable postures and the turning of the head, neck and shoulders towards the back direction. This kind of activities in turn gives several types of musculoskeletal disorders which have been reported by different researchers (Rakhra, 2012).

It is necessary to develop a system that will ease the operation of the tractor operator while monitoring the rear mounted implement during field operation. The conventional method follows direct inspection of working by physically turning back and monitoring the working of implement or by using rear view mirrors. Rear view mirrors can be used for this very purpose as it is very simple with lesser cost of establishment. Apart from these advantages, rear view mirrors are not sufficient enough to monitor the operation of these rear mounted implements.

Modern plan pertaining to solve this situation is to engage the use of CBMS. Several automobile manufacturing companies have already launched the camera based monitoring system. CBMS can be used for the monitoring process of tractor rear mounted implements. It displays the operator's rear view on a monitor mounted anywhere around the tractor cab. The purpose of this study is to develop a CBMS that will be attached to a tractor. More so, the study involves carrying out a physical evaluation of the CBMS attached to the tractor by interviewing the tractor operator under the aspect of his experience and comfort.

2 Materials and methods

2.1 Development of rear mounted implement monitoring system

A survey was conducted among the agricultural tractor drivers at Regional Agricultural Research Station, Tirupati, and Andra Pradesh, India. Major constraints that the agricultural tractor drivers were facing while operating a tractor was found out through the survey conducted. They were asked to address the most difficult task that they had experienced while operating a tractor. After the survey, monitoring of rear mounted implement was identified as critical since majority of the drivers mentioned that as they felt difficult. To monitor the operation carried out so

far, tractor operators need to twist their trunk to monitor what happens at their back. It is essential but still it is a very cumbersome process. As the tractor operator needs to turn back to monitor the implement and equipment, he has to adopt a posture that is not comfortable to him. Hence, an attempt was made to develop a system as an alternative to the turning back of the tractor operator for the effective monitoring of the rear mounted implements and equipment while in operation.

2.2 Components of monitoring system

2.2.1 Camera

The 8 Mega Pixel LED camera as shown in Figure 1 was fixed to the back of the tractor through the help of a camera holder having the same diameter size of that of the camera which was placed in a position where it can clearly capture the implement and equipment while working. The positioning of a camera position plays a major role; hence, the location of the camera and its orientation were fixed by taking into consideration the view that displays majority of operator's views.

Figure 1- An 8 mega pixel camera

2.2.2 Monitor

The system was designed with 8 Mega Pixel LED camera and monitor. The monitor selected as shown in Figure 2 was of 7 inch LCD wide touch screen front view mirror monitor. It supports the use of Bluetooth, MP5, FM transmitter and high quality PAL/NTSC TV (Phase Alternate Line/ National Television Standards Committee) system. NTSC television broadcast 525 lines of resolution whereas PAL television broadcast 625 lines of resolution. Hence, the difference in resolution quality in terms of 100 lines more with PAL will give more visual information on screen thus gives an overall better picture experience and screen resolution. This monitor was used to view the rear side of the tractor along with the implement working action. The display monitor of the camera was fixed to the front side above the dashboard which fell within the viewing range of the tractor operator so that the tractor operator can view both displayed and front view objects comfortably.

Figure 2- A 7 inch camera based monitor

2.3 Evaluation of developed monitoring system

The CBMS was developed in order to reduce the drudgery involved in the monitoring process of the rear mounted implements during operation of the tractor. All tractor operators feel uncomfortable while monitoring the rear mounted implements during field operation. They need to twist their trunk at all times in monitoring the work at the back of the tractor. This is a very cumbersome process which gave room to evaluate the performance of the monitoring system by considering drudgery reduction as one of its performance indices.

2.3.1 Assessment of drudgery during monitoring the rear mounted implement

The monitoring exercise continued till the end of the field operation. The tractor operator has to suffer trunk pain along with shoulder pain; these inconveniences were quantified during the experiment by measuring the tractor operator's oxygen level and heart rate. The amount of oxygen level present in the tractor operator's blood along with his heart rate was measured using a pulse oximeter. The specification of the pulse oximeter as shown in Figure 3 is presented in Table 1. The apparatus is working based on the functioning of a sensor. The sensor comprise of a light source and photo detector. The photo detector in the finger sensor captures and converts the light into

electronic signal. The ratio of light absorbed at the systole and diastole is then translated into an oxygen saturation measurement which is referred to as SpO_2.

Figure 3 Pulse oximeter

The amount of SpO_2 before and after monitoring the rear mounted implement was measured carefully at every 2 minutes interval. While the amount of SpO_2 after installing the rear mounted implement monitoring system was also measured and compared with the values obtained earlier. At the same time, the tractor operator's heart rate was also measured and compared (Sjflot, 1980).

Table 1 Specification of pulse oximeter

Item	Description
Name	Fingertip pulse oximeter
Brand	ChoiceMMed
Display type	OLED display
SpO_2 range	0-100%
Resolution	0.1%
Pulse rate	30 bpm- 250 bpm
Perfusion index	0.1% - 20%
Power consumption	Less than 40 mA
Operating temperature	5^0C - 40^0C
Humidity	15% - 93%

3 Results and discussion

3.1 Development of rear mounted implement monitoring system

A system was developed to reduce the difficulty involved in turning back while on field operation with the tractor and its rear. To overcome this, rear mounted implement monitoring system was developed and attached on the tractor. The camera was fitted at the rear side of the tractor as shown in Figure 4. Monitor was fixed at the front side of the tractor as shown in Figure 5.

Figure 4 Camera attached to the front of the tractor, A- Camera

Figure 5 Monitor attached to front side, B- Monitor display

4.2 Assessment of drudgery during monitoring of the rear mounted implement

Drudgery experienced by the tractor operator while monitoring the working action of the rear mounted implement was quantified and assessed. Heart rate and oxygen level of the male and female agricultural workers with and without camera monitoring system were measured using a pulse oximeter and are given in Table 2 and Figure 6. Presented in Figures 7 to 11 were the observed results obtained for both male and female agricultural workers while taken the measurements for both heart rates and SpO_2 levels. The age brackets for the male and female agricultural workers used for this study were within 29 to 48 years and 24 to 47 years respectively.

Table 2 Average heart rate and average SpO_2 of agricultural workers while monitoring the working of rear mounted implement

Particular	Male		Female	
	Average heart rate (beats min^{-1})	Average SpO_2 level (%)	Average heart rate (beats min^{-1})	Average SpO_2 level (%)
Without camera monitoring system	107.73	93.27	101.22	93.44
With camera monitoring system	98.91	95.73	96.22	96.67

Figure 6 Monitoring of the rear mounted implement without camera system

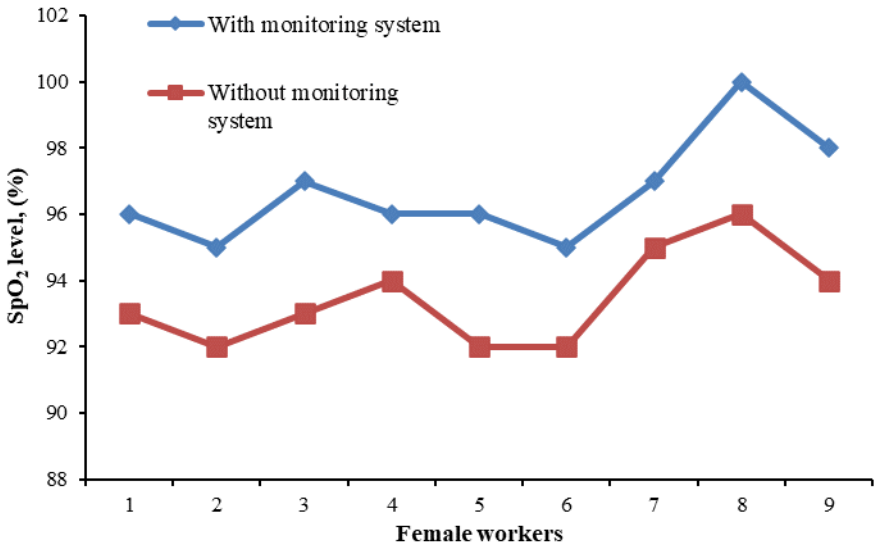

Figure 7 Variation of SpO_2 level of female workers while monitoring implement operation with and without monitoring system

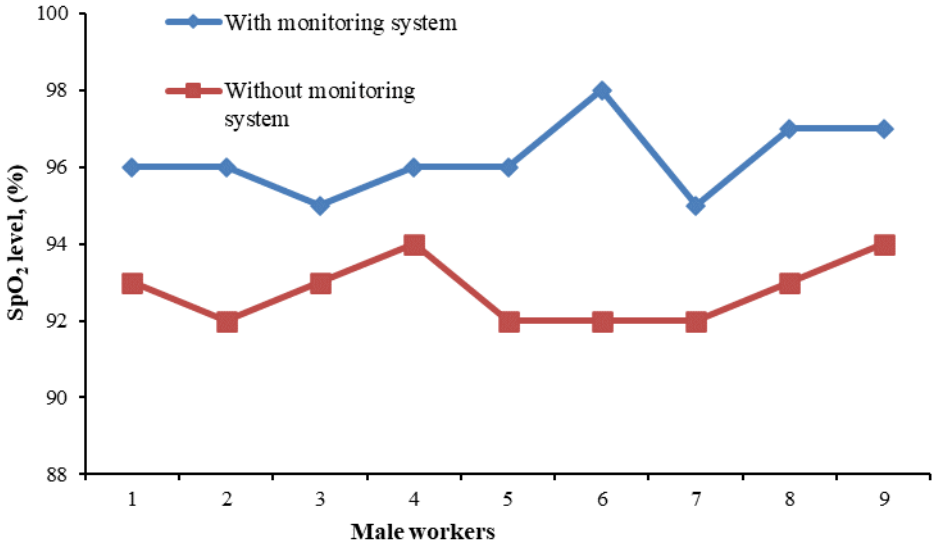

Figure 8 Variation of SpO_2 level of male workers while monitoring implement operation with and without monitoring system

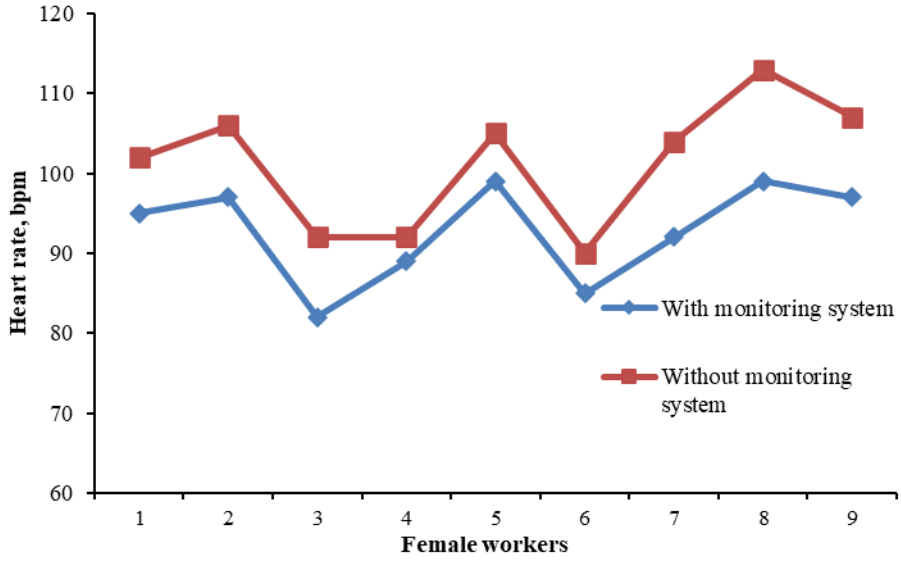

Figure 9 Variation of heart rate of female workers while monitoring implement operation with and without monitoring system

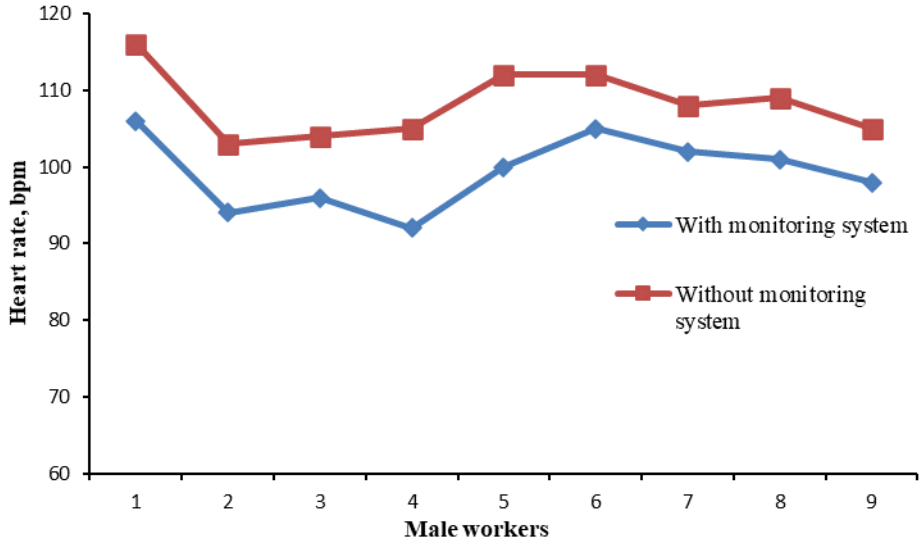

Figure 10 Variation of heart rate of male workers while monitoring implement operation with and without monitoring system

It can be deducted from Figures 7 to 10, that the heart rate value of the various male and female agricultural workers involved increases without the use of the monitoring system than when the monitoring system was used. Similarly, the oxygen saturation level otherwise termed SpO_2 of the various male and female agricultural workers involved decreases without the use of the monitoring system that when the monitoring system was used. This is an indication that rear mounted implement monitoring system played safe health wisely by practically keeping the body within its normal safe range value of 60-100 heart beats per minute and 95%-100% oxygen saturation level during field operation (Healthline, 2022).

Measured values of heart rate and oxygen saturation (SpO_2) level of the female workers while operating with and without developed monitoring system were statistically analyzed and are presented in tables.

Table 3 Statistical analysis of heart rate of female workers working with camera and without camera monitoring system

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Heart rate without camera – Heart rate with camera,	-3.22	0.83	.278	-3.86	-2.58	-11.60	8	.00

Table 4 Statistical analysis of SpO_2 level of female workers working with camera and without camera monitoring system

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	SpO2 level without camera – Heart rate with camera,	5.0	3.536	1.179	2.282	7.71	4.25	8	.003

It can be deducted from Table 3 and 4 that heart rate and SpO_2 level of women agricultural workers were found to be statistically significant while working with and without monitoring system. In addition to this, the heart rates of both female and male agricultural workers were found to be decreases as shown in Figure 9 and Figure 10 while they monitored the working action of the implement through the developed camera monitoring system. This implies that the drudgery involved in the monitoring process of the rear mounted implement while in operation can be reduced by installing a CBMS (Bernhard and Hecht, 2020).

A similar trend was observed in the research work carried out by Sjflot (1980) using big mirrors for rear view monitoring. He has found that the driver's heart rate was clearly lowered with a mirror than without mirror but the difference in heart rate between mirrors and without mirrors was also not significant. Hence, developed camera mounted rear viewing systems have lots of advantages over rear view mirrors as they improve the view of the field and the clear image can be viewed at the bottom of the operating implements.

4 Conclusion

CBMS was analysed in terms of reduction in drudgery. Heart rate and SpO_2 level were measured using a pulse oximeter and that were analysed to quantify the drudgery reduction. Heart rate and SpO_2 level of agricultural workers were found to be

significantly different while working with and without camera monitoring Thus, the drudgery involved in the monitoring operation was eliminated by installing a CBMS to the tractor. Test results showed that the CBMS makes the tractor operator comfortable health wisely when compared to the use of the conventional method that involves the use of inside and outside mirrors.

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