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Installation of Suitable Sensors for Object Detection and Height Control on Combine Harvester

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Abstract

Nowadays, agricultural industry has a lot of advancements and all its devices are mechanized. Combine harvester is one of the necessary devices in agricultural industry. A Combine harvester is a self-motor vehicle or machine that is used to reap grains. This machine has made its own progress, but due to some weakness, it still needs to be advanced. In this paper, we will be investigated New Holland Combine made in United States. First, it examines difficulties of Combine and it has made practical and operational suggestions which can be highly productive and satisfaction for the agricultural industry. In this paper, two sensors were used and it was proposed the best place for these sensors. The first sensor (Infrared sensor) is for detecting the object and the second sensor (Infrared sensor or Ocular sensor) is the height control (regulation) sensor, which is examined the benefits of these sensors for improvement of agricultural machinery by its practical and operational test on Combine. The findings indicated that the first sensor will actually reduce the risk of life to zero and the second sensor will be full satisfaction by working of Combine device. This practical and operational work can yield full productivity. In order to further examine the benefits of the plan and the idea, diagrams were plotted that they are indicated completely satisfactory and successful after the installation of sensor on Combine.

Keywords: *Combine harvester, Sensor of object detection, height control sensor, progress diagram*

I. Introduction

Agricultural population indicates a decreasing and aging orientation, despite the population growth around the world, [1]. Agriculture has an primitive history nearly dates back to thousands of years. Moreover, its promotion has been pushed by performing the several new systems, methods, technologies, and approaches with the time. It apply over one-third of the global workforce [2]. The agriculture is the base of an economy for many countries and accomplishes an important contribution to the development of the economy for underdeveloped countries. Besides, it directs the process of economic success in developed countries. Some studies founded that overall world agriculture uses nearly seventy percent per year available fresh water to irrigate only seventeen percent of the land. On the other hand, the total available irrigated land is slowly decreasing because of the rapidly increasing of food requirements and impacts of global warming [3, 4]. For the past few decades, valuable agriculture has transfomred agricultural production systems. Part of the development has emphasized on robotic automation, to optimize workflow and decrease manual labor. Nowadays, technology is available to automatically leading farming machines and vehicles such as tractors and harvesters along predefined paths using correct global navigation satellite systems (GNSS) [5]. But, a human operator is still required to control the envrionment and intervene when potential barriers appear in front of the vehicle to ensure safety. In order to completely remove the need for a human operator, autonomous farming machines should be operate both efficiently and safely without any human intervention. A technological advancement like this needs extensive studies and experiments to examine combinations of sensors, detection algorithms and fusion strategies. Recently, a few publicly known commercial R&D projects exist within companies that attempt to examine the concept [6–8]. In scientific research, projects investigating autonomous agricultural machinary and sensor positions have existed since 1997 [9]. Since then, a number of research projects has experimented with obstacle detection and sensor fusion [10–18]. However, no public softwares (application) or datasets are available that present the important subjects of multi-modal obstacle detection in an agricultural environment [19]. Growth of the autonomous combine has been gradually developing as described above. When, in the future, a very complex autonomous combine is developed and commercialized, farmers will be able to establish (install) the combine to various fields whenever they might want [20]. Research on sensor technology for precision farming continues to mount. Research involves the measurement of flow rate as well as different characteristics of grain and biomass. The placement of these sensors on the combine can be easily realized when looking at the different functions of the harvester [21]. The combine harvester is a machine that harvests grain crops and is widely used in precision farming. It combines into a single operation a process that previously required three separate operations [22]. The waste straw left behind on the field is consisted of the remaining dried stems and leaves of the crop with limited nutrients. The combine harvester has an on-board computer for data recording, GPS yield measurement, cutting height and width sensors, loss measurement system, chaff spreader, straw chopper, header trailer, etc. Most combines have built-in data acquisition system, but they do not monitor all required parameters in precision farming at the same time [23]. Thus a need was felt to develop a data acquisition system with all onboard sensors for online recording of different parameters in the field [24].

Yap et al (2011) conducted a study about Combine harvester instrumentation system for use in precision agriculture and concluded that computer-based data acquisition system has been used as a main unit to gather and store the real time field data from various sensors and a differential global positioning system to determine the exact latitude, longitude, and altitude of RCH. Modular software allows programming flexibility in developed hardware. The spatial data has been measured and recorded in real time field testing. Sensors have been calibrated in a laboratory under specific conditions, and excellent measurement linearity has been obtained for most of parameters. These maps will be used in precision agriculture to enhance areas of low yield and to improve efficiency of rice [24]. Autonomous farming is the concept of automatic agricultural machines operating safely and efficiently without human intervention. In order to ensure safe autonomous operation, exact real-time risk detection is very important. Humans, animals, trees, other machines, etc. must be detected in due time to conduct risk avoidance. A lidar sensor measures range data to a set of surrounding points and generates a point cloud where each point is indicated by a 3D position. It provides very accurate depth information in 360◦ horizontally and is robust towards changing lighting conditions and has been used extensively for detecting and localizing objects in urban environments by distinguishing between ground and barriers [25]. Kragh et al (2017) conducted a study about Dataset for Obstacle Detection in Agriculture. They realized that Sensing modalities include stereo camera, thermal camera, web camera, 360' camera, LiDAR and radar, while exact position is available from fused IMU and GNSS. Both static and moving barriers, such as humans, mannequin dolls, rocks, barrels, buildings, vehicles and vegetation, are present [26]. Zhao et al [2016] was examined development of uncut crop edge detection system based on laser rangefinder for combine harvesters and understand that an average lateral error of ±12 cm, with a Root-Mean-Square Error (RMSE) of 3.01 cm for the static test, and an average lateral error of ±25 cm, with an RMSE of 10.15 cm for the dynamic test. The proposed detection system indicated a desired performance for edge detection under various conditions in the field, and can provide valuable information for further study [27].

In this paper, two sensors were installed on the combine. Experimental experiments with trial and error and complete systematic examination of these sensors by transferring data to the ECU and then displaying the error on the screen and laptop of the combine device by giving an error to the driver to notice an object or objects or stone or low and high. And by installing these sensors according to the obtained diagrams, the risk of death for both humans and animals and the failure of the device will be minimized.

II. Sensor of object detection

The purpose of this paper is to install sensor of object detection and height control on used Combines in agricultural industry. In this paper, at first, we will describe how the sensor placement and sensor installation and then the advantages of this sensor in today's technology. A Combine harvester is a self-motor machine or driven machine is used to harvest grain in the agricultural industry. These machines can be examined due to life dangerous and hazards resulting in the destruction of the machine, device and other equipment mounted on it. To reduce these hazards and unpredictable damages, it will be introduced two types of sensors in this paper that will eliminate these risks and damages and will reduce its probability to zero. Firstly, we will be discussed sensor of object detection. The sensors can convert physical quantities into electrical quantities. Sensor of object detection are eye sensors that can sense and activate by approaching a human or object or any living being. The advantages of this sensor are the high switching speed, lack of force and pressure, long life span, usable in different environments with hard working conditions. Fig 1 indicated an example of this eye sensor in this section. The sensor of object detection is a type of eye and infrared that it will detect the living object at night. The method of this sensor is to transmit an order to Electronic Control Unit (ECU) after detecting objects and live being, and it reports that humans or living beings are near the cutting nose and may hit this area and damage, and then ECU processed and collect this data and export them to an actuator. This actuator must be installed in a location that can disable the boot area of nose system. We will find that by installing this actuator on the monitor inside the cabin, we can control this operation, well. It must be noted that this actuator should only disable the nose system and not whole Combine system. Then, after cutting the system, the driver can restart system, again and this can alert the driver from the situation by a warming on a monitor display. The best place for installing ECU is under the Combine and on engine, as it is both comfortable (convenient) and not at risk. Fig 2 indicates the exact method of sensor installation and ECU set. Fig 3 shows that how the device indicates error of the object or animal approaching.

Fig 1. How to place the object detection sensor on the combine

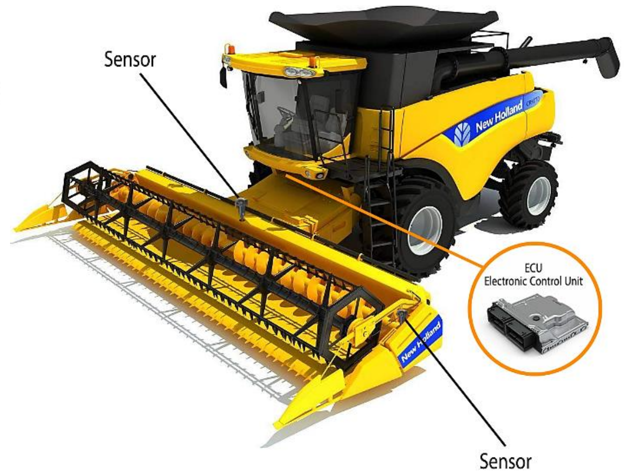

Fig 2. How to place the sensor and ECU on the combine

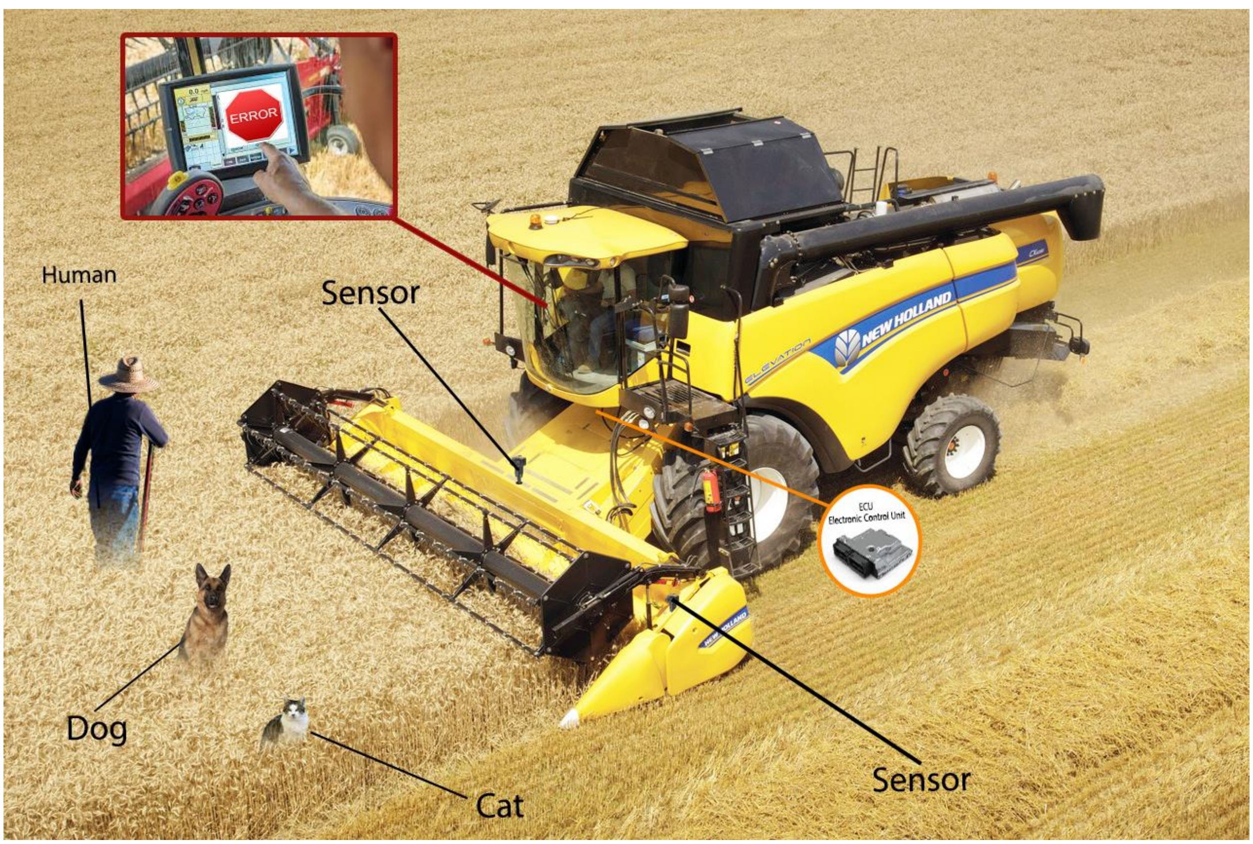

Fig 3. The sensor encounters objects (humans and animals) and gives an error command on the combine monitor

III. How to install sensor of object detection

In this section, we will look at the best location for sensor of object detection. It can be the best place to install this sensor in a Combine on the nose (cutting) are or the front part of the Combine that has the ability to separate from Combine. It is one of the best places to install the sensor and one of the reasons is to be away from exposed to injury. One of the other cases, it has to clearly distinguish a view of the front as clearly as possible and it can accurately diagnose the distance about 6 meters, which is the best place for this site description. To be more precise about installation place, we must recognize the units that work on the nose area, which these units are the cutting shoulder or blades, separators, carousel, helix (auger), respectively; that is the best place to install the sensor at the top of the helix (auger). At its center, where it can accurately identify objects, and also didn't be exposed to injury, it is a good place to install sensor. The first sensor (Infrared sensor) is mounted on the nose (cutting) area by two bases. Then it will be connect to ECU via cable. The exact location to accommodate the ECU is under the Combine that will be attached to cockpit by fastener. ECU is attached to the back of the monitor by cable and by steering the sensor to the ECU, the ECU collects data and sends a command to the actuator attached to the monitor. A warning sign will appear on the monitor, if human or animal is near 6 meter, and the driver is aware of the problem and the system control.

IV. Height Control Sensor

The second sensor (Infrared sensor or Ocular sensor) that is mounted on the Combine is the height control sensor. This sensor is also installed like previous sensor as eye with previous productivity on place that has minimum damages. Fig 4 indicated the its exact location and installation. By using of this sensor, it can reduce the damage that may occur to a Combine system when harvesting a production from good quality fields. It may be damaged or broken by stone or any other object to cutting blades. This sensor is more effective in places where the terrain has low and high, high slope, rocky terrain and it can be used mostly. The aim of this installation is removed these damages. Height control sensor, as the name indicates, adjust the height in such a way that the machinery or vehicles should not be harmed by the body or not at all, and in Combine has the same efficiency; that soil didn't penetrate the seed storage, and no object will damages the blades and other Combine systems.

V. How installation of height control sensor

The sensor should be places on the nose or section of cutting area that accurately diagnose the height and slope of the earth. The best place of installation this sensor is the vicinity of the nose close to hydraulic jack because it is both prone to damage and can detect the height well. The fig 5 indicates how the sensor is installed exactly. This sensor is detects like the first sensor (Infrared sensor) and its alarming will function as the first sensor. How to do so is that the rock or roughness in earth surface is transmitted by a signal sensor to the electronic control unit (ECU), which is embedded in under the driver's cabin. This alarm means that height didn't regulate and ECU will collect and process these data and it send a command to actuator and they can be mounted on the hydraulic jacks that move up and down nose section to control jacks automatically. Or even, it can be send an error on monitor display so that the driver can understand the holes and slopes and rocks around the floor. Fig 6 indicates this sensor and how it is prone to encounter rocks and roughness.

Fig 4. How to place the height adjustment sensor on the combine

Fig 5. How to place the sensor and ECU on the combine

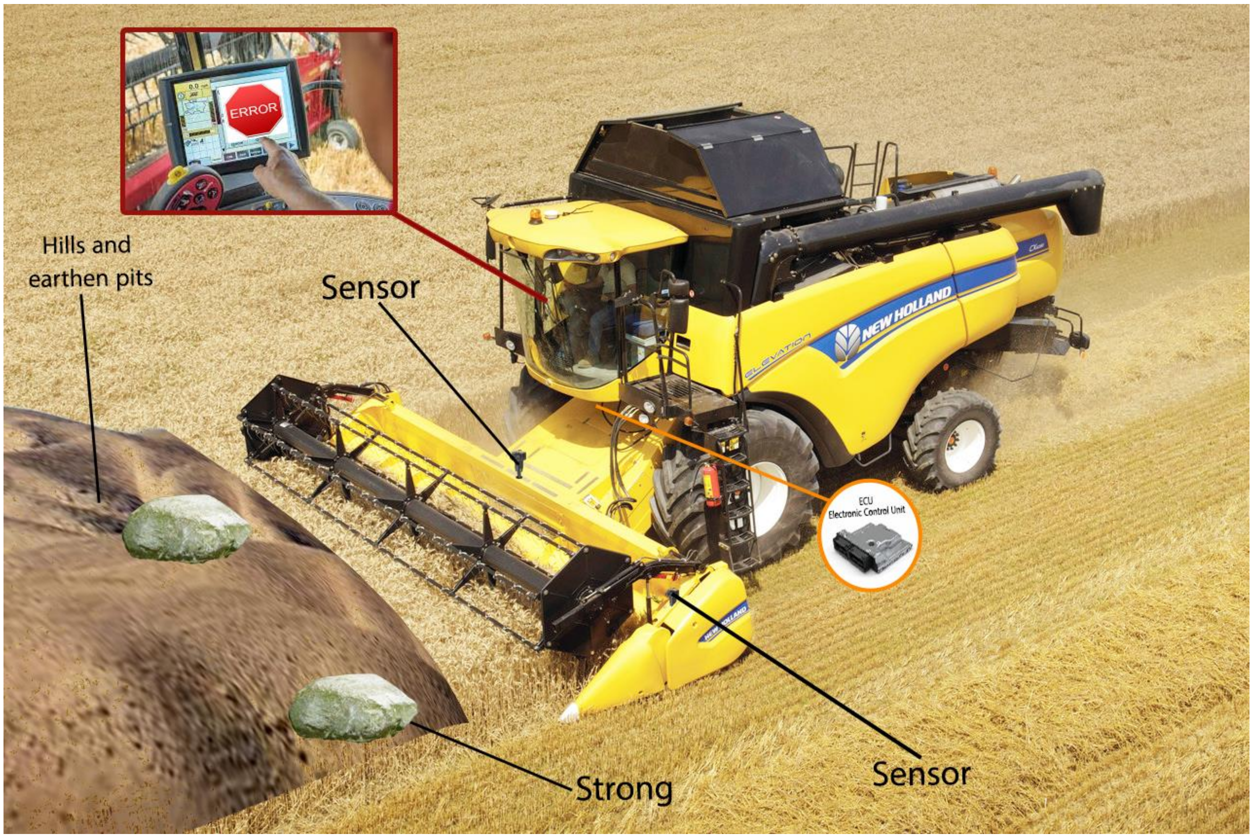

Fig 6. Facing the sensor with uneven ground and small and large stones and error command on the combine monitor

VI. Diagrams

The purpose of implementing the idea and installing sensors on a Combine is prevention of life risks that occurs for humans and animals, and financial losses reduces to zero that are for Combine and the production, and the farmer is suffering from it. In order to examine and verify the installation of the first sensor (Infrared sensor), refers to Fig7. Fig 7 compares the number of morality and disability (defect) of humans and morality in animals in recent years. Installation of this sensor will set this value to zero for 2021 and the future. In 2000, Combines had a low technology that had 85 morality and disability (defect) in humans and animals. In 2000 and 2010, the maximum morality and disability (defect) is 90 that by updating technology, these number will be reduced 59 in 2020. As you can observed, by designing of new systems, the number of morality and disability (defect) will be reduced and by installing sensor of object detection on Combine, this value will be zero, and we will observed no morality and disability (defect) in human and morality in animals. The second diagram indicated in Fig 8 is the identification of the percentage imported soil in the final production. In 2000, the percentage of soil in production reached 16%, or in 2007, the percentage of soil has been processed, that this value becoming less than 10% by updating technology in 2020. This percentage shows a drop in the price of the harvested production and the farmer's dissatisfaction from harvested production and machine. By designing and installation of height control sensor, the percentage of the imported soil by the product has reached zero, which will result in the high quality harvest and full satisfaction of the farmer. The third diagram that indicated in Fig 9, is related to how the Combine damage is caused by the impact of the rock or any other object on the nose section and blades in earth roughness. In 2000, rate of injury is 65% and in 2003, which accounts for the maximum percentage, 80% has caused the Combine to be damaged. By updating the technology, this value has reached a minimum about 48% in 2020, which caused a cost of finished repairs on a Combine machine. By installation the height control sensor, these damages has reached zero and we will observed no damage such as fracture or tilt, and difficulties related to nose system.

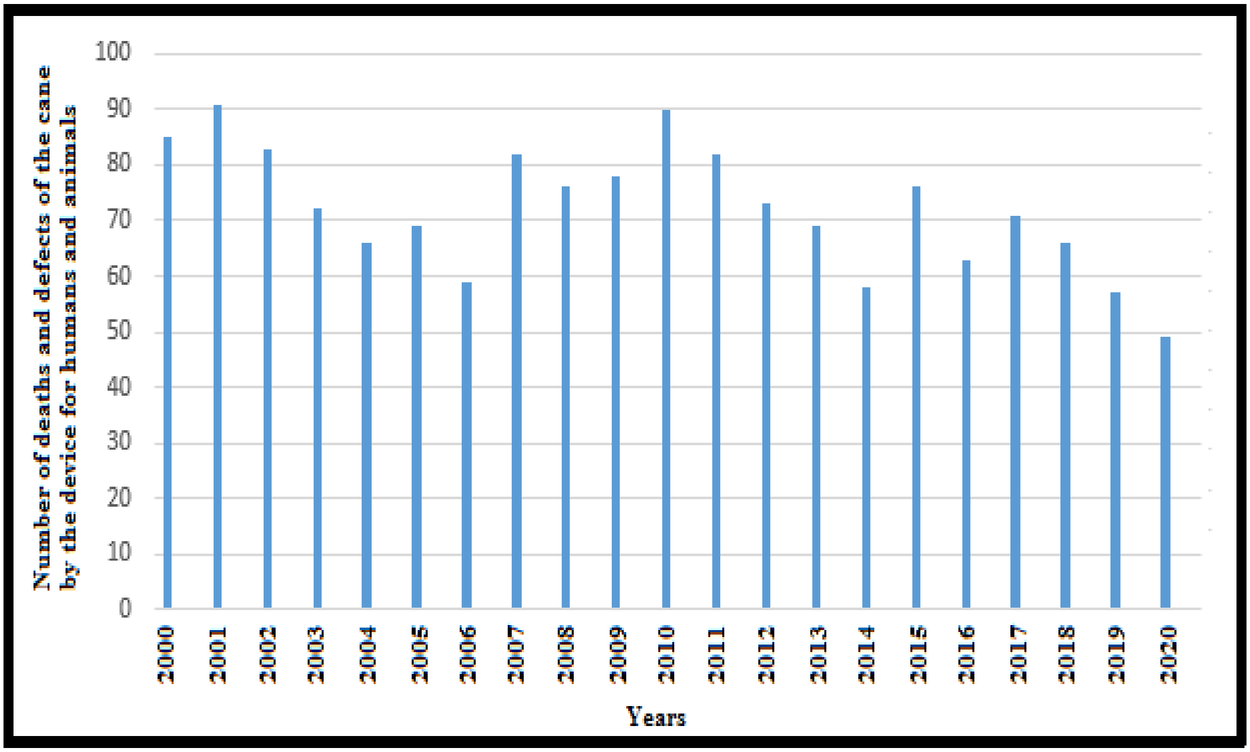

Fig 7. A comparative graph for the number of human deaths and disabilities and animal mortality in recent years

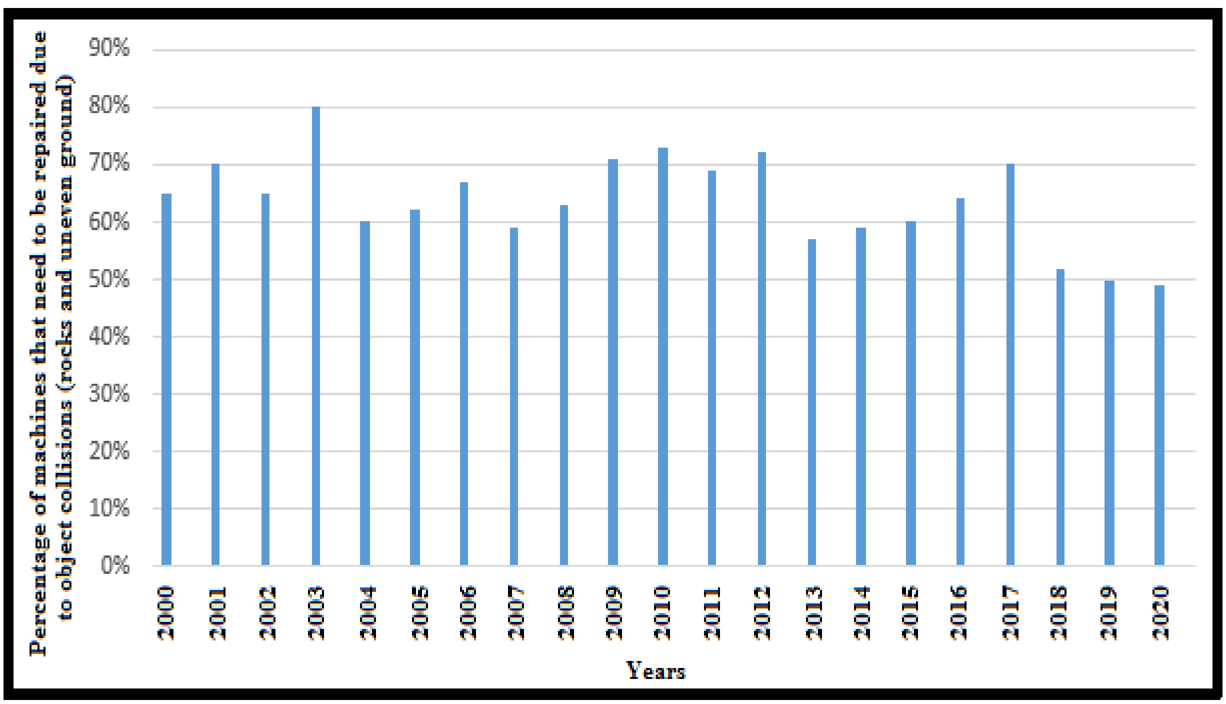

Fig 8. Chart identifying the percentage of soil introduced into the final crop in recent years

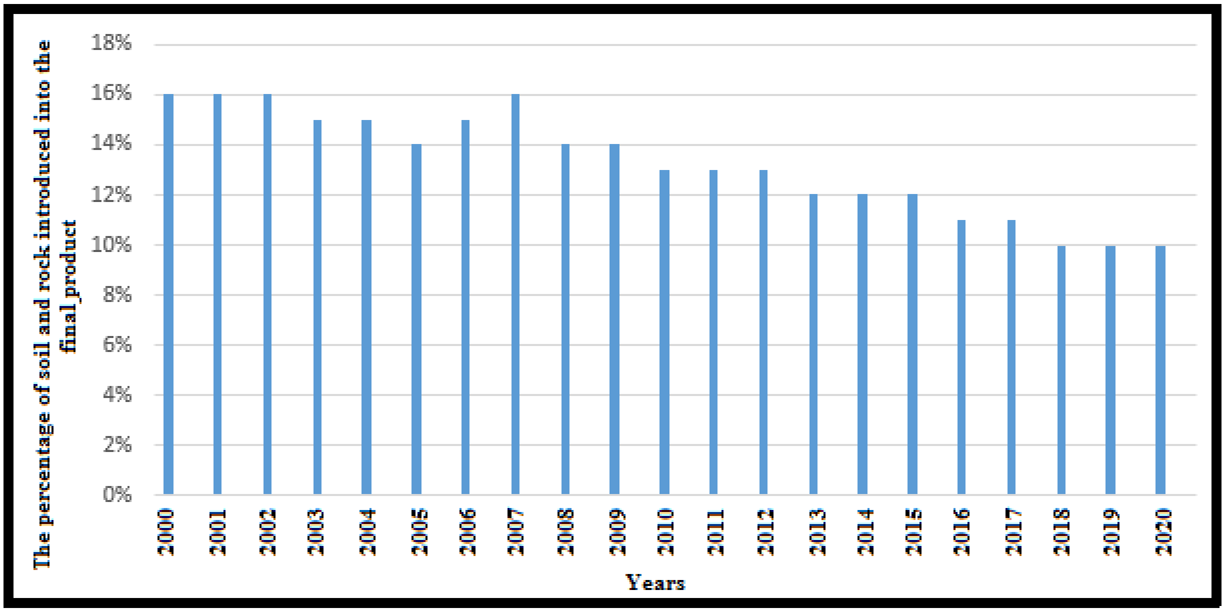

Fig 9. The extent of damage to the combine due to the impact of stones or any other object on the nose and blades on uneven ground in recent years

VII. Conclusions

The sensors can be had many applications in agricultural machinery, which is why they are sufficient to increase their performance and pursue the farmer's satisfaction. In this paper, two sensors are placed on a Combine, which will help contribute significantly to the device. In sensor of object detection, the life risk will reached to zero completely, and we will not witness the loss of humans and animals. This sensor, which has been done by a lot of experiments, has an error message on a monitor display to 6 meters implementable in the day and night. The second sensor, which is height control (adjustment), will also be used to detect areas with large roughness. Also, objects and stones have an operational by this installed sensor. The second sensor (Infrared sensor or Ocular sensor) caused us no longer to observe the soil composition and final production in agricultural products in a Combine. Also, when hitting an object or rock on the ground, to prevent damage to the blades, the sensor will be disconnected by actuator and its alarming. The most important principle in this paper is the satisfaction that farmers have encountered in this plan. The results in diagrams also shows a satisfactory percentage of the plan and idea that indicate we cause the progress of the agricultural industry and also it has lower losses or even no losses.

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