



Communication

Advances in IoT and Smart Sensors for Remote Sensing and Agriculture Applications

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Abstract: Modern sensors find their wide usage in a variety of applications such as robotics, navigation, automation, remote sensing, underwater imaging, etc. and in recent years the sensors with advanced techniques such as the artificial intelligence (AI) play a significant role in the field of remote sensing and smart agriculture. The AI enabled sensors work as smart sensors and additionally the advent of the Internet of Things (IoT) has resulted into very useful tools in the field of agriculture by making available different types of sensor-based equipment and devices. In this paper, we have focused on an extensive study of the advances in smart sensors and IoT, employed in remote sensing and agriculture applications such as the assessment of weather conditions and soil quality; the crop monitoring; the use of robots for harvesting and weeding; the employment of drones. The emphasis has been given to specific types of sensors and sensor technologies by presenting an extensive study, review, comparison and recommendation for advancements in IoT that would help researchers, agriculturists, remote sensing scientists and policy makers in their research and implementations.



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Keywords: sensors; smart sensors; AI; IoT; remote sensing; agriculture applications

1. Introduction

Sensors are most commonly used in numerous applications ranging from body-parameters' measurement to automated driving. Moreover, sensors play a key role in performing detection- and vision-related tasks in all the modern applications of science, engineering and technology where the computer vision is dominating [1–15]. An interesting emerging domain that employs the smart sensors is the Internet of Things (IoT) dealing with wireless networks and sensors distributed to sense data in real time and producing specific outcomes of interest through suitable processing [2,6,16–26]. In IoT-based devices, sensors and artificial intelligence (AI) are the most important elements which make these devices sensible and intelligent. In fact, due to the role of AI, the sensors act as smart sensors and find an efficient usage for a variety of applications, such as general environmental monitoring [2,9,19,22,27–30]; monitoring a certain number of environmental factors; weather forecasting [15,21,29,31–33]; satellite imaging [21,27,34–38] and its use; remote sensing based applications [1,13,21,37,39]; hazard events' monitoring such as landslide detection [29]; self-driving cars; healthcare [4,6] and so on. In reference to this latter sector, recently the usage of smart devices has been hugely increased in hospitals and diagnostic centers for evaluating and monitoring various health conditions of affected patients, remotely as well as physically.

Practically, there is no field of science or research which performs smartly without using the modern sensors. The wide usage and need of sensors; and IoT employed in remote sensing, environment and human health monitoring make the applications as intelligent. In the last decade, the agriculture applications have also included the utilization of many types of sensors for monitoring and controlling various types of environmental parameters such as temperature, humidity, soil quality, pollution, air quality,

water contamination, radiation, etc. This paper also aims to highlight the use of the sensors and IoT for remote sensing and agriculture applications in terms of extensive discussion and review.

First, the contribution in the area of IoT and sensors used for various applications related to environment, agriculture and remote sensing is highlighted in the Table 1, where methods used, contributions and limitations are presented for a selected number of papers. In [18], a critical review and recommendations are presented with the focus on various types of sensors and IoT devices, used for monitoring some parameters of the environment such as water quality, air quality, radiation, sound pollution, etc. The research study recommends some peculiar to-do-objectives for implementing viable environment monitoring systems smartly with the help of sensors, IoT and AI. Advances in modern sensors, their physics and implementation strategies have been discussed vividly in [8]. This can be used as a good manual for studying and choosing an appropriate sensor for a specific application. Different types of IoT, their designs, implementations, challenges, privacy issues are discussed in [2,6,17,19,40,41]. Putting these characteristics altogether becomes very important to understand the most suitable type of IoT that could be viable for an application meeting the usage requirements. Edge computing has been discussed and suggested in [5] as an important technique for developing effective IoT applications. The different types of sensor networks used in deploying the sensor and the IoT-based applications are discussed in [20–22,24,28,42–44]. Miniaturized pervasive sensors are discussed in [10] that highlights how sensors can be miniaturized for intelligent applications in many fields so that the portable usage can make their utilization more flexible. Here, sensors used for agriculture and remote sensing are also discussed. A comprehensive survey of IoT and their applications is presented in [6] by highlighting the suitable choice of IoT in the desired application of remote sensing.

Table 1. Research studies, theories and surveys on IoT and Sensors.

Research/Survey Category	Method Used, Contributions and Limitations
Smart Monitoring [18]	IoT and sensors are discussed used in Environment Monitoring Systems for assessment of quality of water, air and radiation. The work highlights critical review and recommendations.
Modern Sensors [8]	Different types of sensors with their physics, implementation and scopes are covered. This is a research-based book which highlights advances in modern sensors used for numerous applications including agriculture and remote sensing.
Internet of Things [2,6,19,45]	Theory, principles, review and survey of various types of IoT are discussed. A good combination of theory and practices on IoT including privacy issues is presented. Implementation strategies and the challenges are discussed in detail.
IoT and Edge Computing [5]	Edge Computing is the main contribution for IoT application. Open source model and framework of IoT are suggested. The emphasis is on general purpose applications rather than only agriculture or related uses.
Sensor Networks [20–22,24,28,30,42–44]	Different types of wireless sensor networks are the focus of these papers. Sensor networks used in the deployment of various types of IoT and sensors are discussed with the potential of different networks for various applications.
Pervasive Sensors [10]	Miniaturized Pervasive Sensors are used for health monitoring. In the development of smart cities, smart health monitoring systems, the sensors play the most significant role and for this reason miniaturized pervasive sensors are discussed in detail with emphasis on the scope of implementations. This could be used for agriculture and remote sensing applications as well.
IoT: Comprehensive Survey [6]	A Comprehensive Survey of IoT and their applications are discussed. This paper highlights various surveys on IoT and their applications which would help in choosing appropriate smart sensors and IoT for specific uses in remote sensing applications.

There are numerous types of sensors and their classification is based on the physics involved; fabrication processes; performance metrics, application, etc. The focus of the sensors in this paper is on smart sensors and IoT especially used in remote sensing and agricultural applications.

The paper is organized as follows: in the Section 2, Smart Sensors for Remote Sensing Applications are introduced, while IoT for Remote Sensing Applications is discussed in the Section 3. Smart Sensors and IoT for Agriculture Applications are jointly discussed in Section 4, by explaining how advanced technologies employed in modern agriculture can help in improving its management and outputs. Discussion is carried out in Section 5, and Conclusions end the contribution in Section 6.

2. Smart Sensors for Remote Sensing Applications

As discussed in the previous section, the remote sensing applications become interesting and powerful if the smart sensors are used for smart sensing and detection of real time data and their analysis. Figure 1 depicts an application scenario in which the active and passive sensors [46] are used in remote sensing applications, which can range from those including navigation, surveillance, communication [3,5,16,21,26,39], forecasting [13], biological research, earth resource monitoring, up to atmospheric condition monitoring [26,43,47], etc. Weather monitoring, navigation, communication, forecasting assistance are major application areas of remote sensing employing different types of sensors. The sensors used in such applications behave smartly due to artificial intelligence (AI) techniques embedded in the sensors, also based on IoT for the specific purposes.

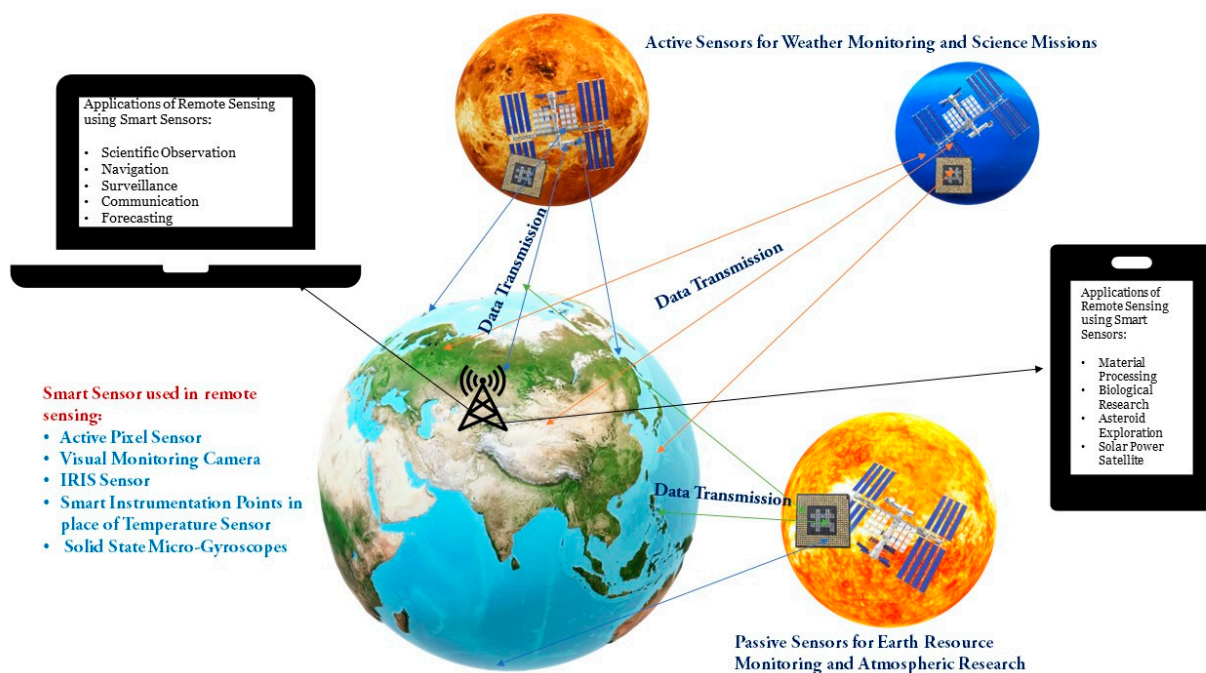


Figure 1. In [48,49], clarity of theory and concepts of different types of smart sensors are highlighted with explicit examples and their possible applications. Sensing impact is presented in [50] with focus on scope and impact analysis of various types of sensors used for industrial and other applications. Precision agriculture and satellite data processing are discussed in [35], which utilizes the remotely sensed LiDAR data and helps in smart agriculture applications.

Although, research papers on smart sensors for remote sensing applications are limited, few major research works with potential impact have been summarized in Table 2. In [48,49], clarity of theory and concepts of different types of smart sensors are highlighted with explicit examples and their possible applications. Sensing impact is presented in [50] with focus on scope and impact analysis of various types of sensors used for industrial and

other applications. Precision agriculture and satellite data processing are discussed in [35], which utilizes the remotely sensed LiDAR data and helps in smart agriculture applications.

Table 2. Smart Sensors for Remote sensing applications.

Research	Method Used	Contributions and Limitations
Understanding smart sensors [48,49]	Theory and fundamentals of smart sensors	Smart sensors for a wide range of applications are covered in the studies with their potential use for a variety of real time uses including agriculture and remote sensing applications.
Remote monitoring and its impact [50]	Development actors for sensing impacts	Sensing impacts of sensors, marketability and scope are discussed. This scope of the sensing application is very limited in this contribution.
Remote Sensing and precision agriculture [35]	Satellite data processing and precision agriculture	LiDAR-based remotely sensed data are used for precision agriculture applications covering the soil quality estimation, crops selectivity and enhanced productivity. More focus is on agriculture applications and the less emphasis is on remote sensing aspect.

3. IoT for Remote Sensing Applications

As already underlined in previous sections, IoT finds a wide usage in data acquisition, processing and interpretation in many fields of interest, and Remote Sensing is one of them, being an important area of signal processing research and studies. The smart sensors are in fact used in a wide number of applications related to environmental monitoring such as for instance air quality control; water contamination assessment; water contamination monitoring; radiation assessment, that also contribute to monitoring the territory, the environment and may impact on several fields as listed below. IoT for Remote Sensing Applications is another exciting area of interest where IoT empowers smart systems to detect, sense and analyze various parameters that assist in a robust monitoring of the environment. Figure 2 shows a typical diagram of the scenario in which IoT is used in a number of applications related to Remote Sensing. Some of them are listed as following:

- Forest monitoring and assessment of factors related to plants and animals [13,37,39].
- Agriculture monitoring and assessment of soil quality, water quantity [1,9,20–22,25,27,28,43,51–53].
- Industrial monitoring [20,33].
- Data monitoring [2,21,29,37,47,51].
- Security and surveillance applications [3,31,46,54].

The applications employing smart sensors and dealing with the environment monitoring are described based on the evaluation of various factors, as discussed ahead. As shown in the Figure 2, the role of IoT in Remote Sensing implies the employment of a shared cloud space where a number of sensing, processing and signal transmission components are connected together and share information on parameters and areas of interest.

A number of research papers and articles on IoT for Remote Sensing applications have been analyzed, by summarizing their findings, limitations and their potential impact in Table 3. As highlighted in the table, geospatial analysis, environmental informatics and IoT are used in [55], for analysis of environmental research data which can be utilized for remote sensing and the interpretation for various uses such as weather forecasting, soil and moisture evaluation, etc. is given. In [54], a time series method is applied over Sentinel-1 SAR data, useful for management and classification of various types of crops. This work appears to be helpful both for remote sensing and agriculture applications. A statistical analysis used for agriculture applications using Remote Sensing data is presented in [56], as a handbook issued by United Nations (UN) food and agriculture organizations. A Remote Sensing communication model is presented in [39] showing how a time-sensitive wild fire detection is achieved through Remote Sensing data. In [52], hyper spectral imaging

is used in agriculture applications, and data classification is performed with the help of a number of regression techniques. In other publications, Remote Sensing utilizing IoT has been discussed, such as precision agriculture using Remote Sensing [1,21,27]; vulnerability analysis [33]; Remote Sensing in agriculture using IoT and sensors [1,21,35,57]; and inland water quality assessment [38].

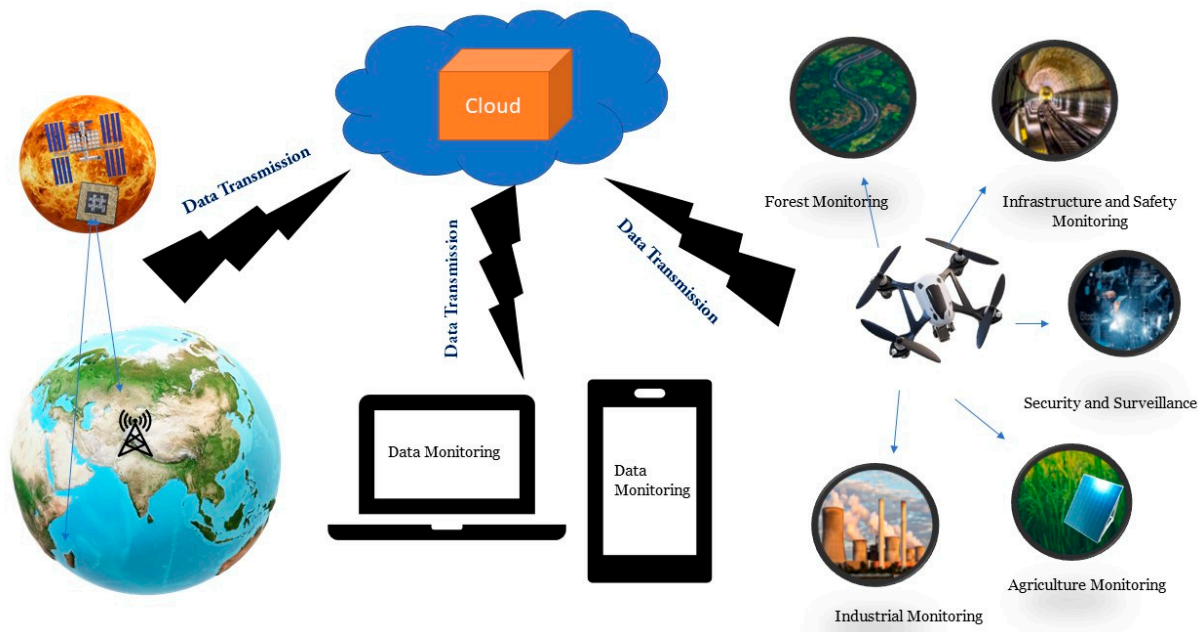


Figure 2. Highlights of the role of IoT in remote sensing applications.

Table 3. IoT for Remote sensing applications.

Research	Method Used	Contributions and Limitations
Geospatial Analysis and IoT [55]	Geospatial Analysis, IoT and Environment informatics are used.	Environmental Informatics obtained through IoT and the spatial analysis of geospatial techniques help in the interpretation of remotely sensed data. Useful for general purpose environmental research, the analysis however is useful in Remote Sensing applications.
Crop classification [54]	Time series analysis, crop classification.	Sentinel-1 data is used for crop classification and management using time series method and SAR (Synthetic Aperture Radar) data. Classification performance is evaluated in terms of F-1 score and other metrics. However, the method cannot be generalized for all different crops from any region.
Agricultural statistics analysis [56]	Data analysis and statistics.	The report presents a complete agricultural statistical analysis using Remote Sensing data.
Remote Sensing communication [39]	Remote Sensing communication model are used for wildfire detection.	The model presented helps in detection and avoidance of wildfire and associated hazards. The modeling is not used for dynamic hazardous cases.
Hyperspectral imaging technology [52]	Hyperspectral imaging techniques are used for agriculture applications. Regression techniques are used in classification.	UVA-based, satellite-based and airplane-based hyperspectral image analysis is used for agriculture applications.

4. Smart Sensors and IoT for Agriculture Applications

Modern agriculture employing advanced technologies such as AI and smart sensors, can produce increased yields with appropriate crop quality assessment [16,24,25,54,58], crop classification and soil moisture measurement [20,21,25,43,51,52,59]. In Figure 3, we can see that smart sensors [3,6,8,16,26,28,48,60–62] are used in the agriculture sector by including modern sensors, advanced AI techniques [26,27,60], soil health monitoring systems, animal-husbandry [63] applications, crop yield [16,23,25,27,51] analysis. The role of smart sensors is extremely important in agriculture and pharma sectors where not only the productivity is enhanced but the sustainable growth is also achieved. The smart sensors and IoT change the conventional agriculture practices into smart farming that helps in empowering the farmers all across the world.

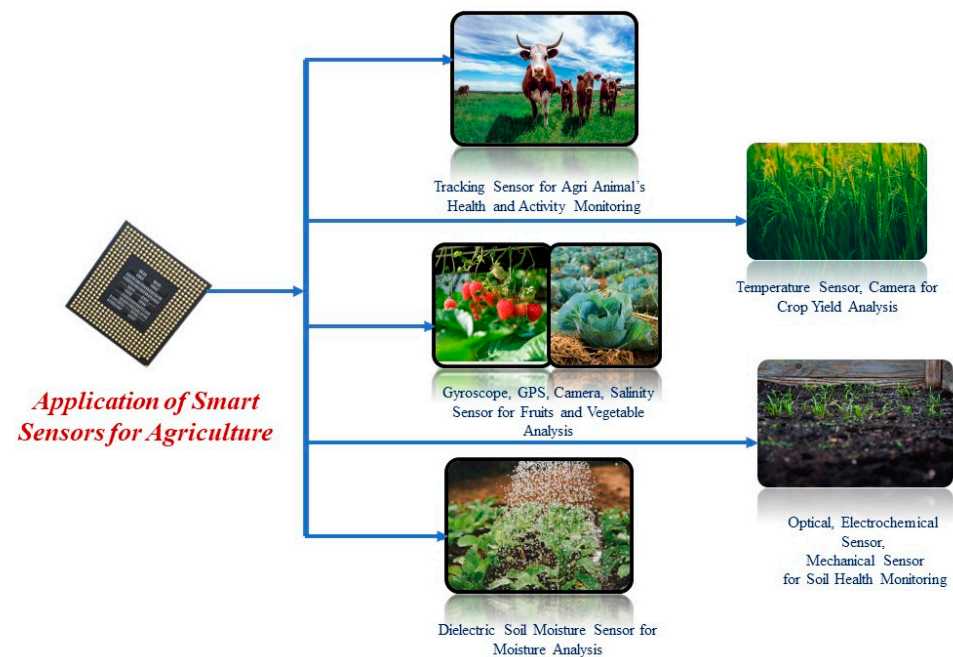


Figure 3. Smart sensors for agriculture applications.

In Figure 4, the IoT which is used in the agriculture sector is highlighted with the help of typical applications such as crop disease [24,27] diagnosis, soil fertility analysis [25], erosion analysis, pesticide and fertilizer control [25–27], crop quality assessment, optical irrigation [16,23,27,51,64], seed quality [1] and smart IoT-based alarm systems for the control of the agriculture production at various stages.

Figure 4 shows the usages of IoT in agricultures, with possible domains of agricultural applications highlighted in a foreground scheme. The research work in the area of IoT and smart sensors used for agricultural applications is depicted in Table 4, where other references are introduced and analyzed. In [57] Big Data and Remote Sensing data are managed and processed for precision agriculture. In [58], cropland agriculture is implemented and crop classification achieved, by showing how the precision agriculture utilizing remote sensed data enhances crop management. However, the work focusses on near-real time implementations, and it can be extended for actual real time usage of the precision agriculture. This is further discussed and explained in [1] using latest sensors for farm management and post-harvest applications. Infrared thermography methods are used for data sensing and the sensors are used for capturing the cultivation data. However, the robust and wide range of sensors can be used to further augmenting the performance in digital and precision agriculture. In another work on precision and smart agriculture [20], smart soil moisture sensors and IoT are used but the long term stability and wood substrate in the soil are major issues as discussed in the paper. Deep learning is used in [46] for multisensory data analysis used in security and surveillance applications. In [22], rural agriculture is

explained making an effective use of sensors, IoT, ZigBee and Arduino. A number of environmental parameters such as temperature, moisture and soil quality are estimated for guiding the farmers about suitability of crop type and other associated factors, and this can be extended for larger areas. Sensor and IoT-based smart farming is discussed in [22], employing temperature, humidity and moisture sensors. The sensory data are interpreted with the help of IoT which assists in better monitored and planned agriculture yields.



Figure 4. IoT for agriculture applications. A corn crop has been chosen as a background to create a scenic view and in the small box the picture of a ripe and healthy crop ready for harvest is shown as an example.

Table 4. IoT and smart sensors for agriculture applications.

Research	Method Used	Contributions and Limitations
Agriculture data management [57]	Big data, remote sensing and precision agriculture	This gives analysis of agricultural data captured through Remote Sensing techniques and IoT, which are simplified using the Big Data concept. The work is applied for precision agriculture. However, specific sensors or IoT are not suggested in the work.
Cropland agriculture [58]	Crop classification and precision agriculture	Non-conventional agriculture with improved productivity is implemented as precision agriculture method for crop management and crop classification. This work suggests that the real time monitoring of crops needs to be achieved for larger regions.
Sensors in agriculture [1]	Infrared thermography methods, agriculture sensors and digital farming	Precision agriculture is used for farm management, soil sensing and post-harvest uses. Wide range of temperature and humidity sensors can also be used for better sensing.
Soil moisture sensors and IoT [20]	Printed disposable sensors and IoT	Soil moisture is measured using the sensors and IoT that assist in precision agriculture. Sensing characteristics are estimated for appropriate farming. Long term stability is a major concern in the work.

Table 4. Cont.

Research	Method Used	Contributions and Limitations
Multisensory data and analysis [46]	Deep learning for counter UAV applications	Multisensory data are interpreted using deep learning for security and surveillance applications useful for agriculture uses. Sensor models and classification techniques are employed for better security and surveillance. The framework of sensors and classifiers is used rather than a robust or general purpose method.
Sensor network for rural agriculture [22]	Wireless sensor network, IoT, ZigBee and Arduino	Rural agricultural environment was created with the help of wireless sensor network for creating an effective rural agriculture. The scope of the work needs to be extended for larger areas since the rural economy is mainly based on agriculture.
Smart farming [25]	Sensors and IoT	Optimal monitoring of farming conditions and smart agriculture are discussed operating over IoT and sensors. Soil moisture, temperature and humidity are monitored for better and smart farming. This prototype needs to be extended for wide areas' deployment.

Based on Remote Sensing data and other agricultural data collected with the help of sensors, low cost platforms have been developed for smart farming system with controlled and monitored environmental factors. This type of development requires IoT and UAVs (unmanned aerial vehicles) which operate on the low to middle cost platforms [65–68]. Thus, the agriculture can be improved by making it smart with the help of cutting edge technologies that include Arduino based controls; machine learning and deep learning based approaches, as reported in [69–74]. As a novel platform developed for smart agriculture, it is worth to mention the Flying IoT, which has been tested in real time scenario and its performance has also been evaluated in the context of smart farming carried out in different countries. Crop quality assessment, drought management, losses due to drought are assessed using the low-cost platforms based on IoT. The ground water irrigation monitoring and the definition of its appropriate amount, for instance, are an example of important factors, aimed at improving the crop control, used in implementing remote sensing techniques in smart farming. There are in fact some indices used in smart agriculture which can benefit the employment of using the IoT and the sensor networks. A few major indices are as follows:

- Evaporative stress index (ESI).
- Vegetation health index (VHI).
- Enhanced vegetation index (EVI).
- Standardized anomaly index (SAI).

The above indices or metrics are computed utilizing satellite-based Remote Sensing data. To give an idea of their importance, it is worth to highlight how the value of ESI is expected to be always good since an indication of the agricultural drought. The VHI indicates the health of vegetation and EVI shows the improvement in the VHI. Calculation of SAI is based on the other indices.

5. Discussion of the Review

The methodology for completing this work includes critical review of most important research in the field of IoT and smart sensors used for Remote Sensing and agriculture, also because smart agriculture depends on remotely sensed data and forecasting to a considerable extent. The review is followed by a comparison of different types of smart sensors and IoT used, based on types of sensors employed, methodology adopted, application and challenges. Based on the study and review of the selected research works in the area of IoT and smart sensors used for Remote Sensing and agriculture applications, the following challenges are seen as major shortcomings of the existing literature, as follows:

- No specific method has been suggested as robust method for smart agriculture. This means that a specific type of smart sensor is not recommended for numerous applications. In fact, a set of sensors and different IoT-based devices are generally used invariable in the applications. Thus, a framework of smart sensors needs to be highlighted for agriculture and Remote Sensing applications, in particular.
- Wide range of sensors and IoT devices are used in different pieces of research which poses a major challenge on choosing appropriate sensors for a particular application.
- Statistical analysis and modelling for assessment of performance are missing in most of the researches.
- The interoperability issues of sensors and their deployment are also important limitations.
- The amount of research in the specific areas of IoT and sensors for Remote Sensing applications is very limited. So, the research efforts in these sectors needs to be strengthened.
- The applications highlighted in various existing literature cover diverse areas of usage of smart sensors that again pose challenges related to robust practices or approaches. This means that the methods used while implementing the sensors are not specific in various studies already made in the literature. This observation is based on the exploration of various types of literature reported by important databases (shown in Tables 5 and 6). The research suggests that sensors employed are not robust due to the fact that environmental condition, image noise, artefacts and many other factors are invariably considered in most of the articles, and similarly are the sensors required as per the necessity, namely for addressing the issues involved in the applications. As regards the research on smart sensors and IoT specifically for remote sensing and agriculture applications, this is very limited and thus it has been very difficult to bring out a substantial conclusion here about robustness. This is why a framework of sensors for covering most of the scopes of remote sensing is recommended, that may include a set of sensors as well as the common types of sensor networks viable for such applications in smart agriculture. The suggested framework may be useful because the number of environment factors and other issues involved in these applications can be broadly classified and the specific sensor requirements can be categorized for further extension of their employment.
- Selection of environmental parameters that affect agriculture sector needs to be judiciously made and for this, robust set of parameters can be investigated.
- The smart sensors especially for monitoring the parameters involved in weather forecasting for farmers should be appropriately chosen for the specific application.
- The design of IoT has been a less touched are in the field of IoT and smart sensors and thus specific design methods need to be researched more.

Table 5. Research contributions and their impact (Science Direct Database).

Research	Number of Research Contributions				
	2017	2018	2019	2020	2021 (Till Date)
IoT for remote sensing applications	424	627	941	1334	913
Smart sensors for remote sensing applications	1289	1505	2028	1316	1
Smart sensors and IoT for agriculture applications	142	215	407	679	449
Smart remote sensing systems	1628	1903	2230	2904	1906

Table 6. Research contributions and their impact (Google Scholar-MDPI, IEEE and ACM Databases).

Research	Number of Research Contributions		
	Google Scholars Including MDPI (2017–2021)	IEEE (2017–2021)	ACM (Last 5 years)
IoT for remote sensing applications	17,000	252	153,182
Smart sensors for remote sensing applications	16,400	226	153,554
Smart sensors and IoT for agriculture applications	17,100	319	153,553
Smart remote sensing systems	63,500	575	151,173

In Table 5, we have shown the number of research publications of various works in the field of IoT and sensors for Remote Sensing applications. The data are taken from Science Direct source of research in the field of IoT and smart sensors and it is obvious from the data that the amount of work needs to be increased though a certain increase is reported in recent years. The robust sensors and a framework of IoT are actually required to design IoT-based Remote Sensing applications that can help in environment monitoring, weather forecasting as well as in smart or precision agriculture. As it can be seen in Table 5, the research in the field of smart sensors and IoT used in Remote Sensing and agriculture applications, is gaining momentum. However, much has yet to be carried out on implementation challenges and robustness while deploying the sensors in smart agriculture systems. In addition to IoT and sensors, focus on sensor network is also needed as the network plays significant role in deployment and poses some of its own specific issues. The satellite data and its processing can be of good help in estimating weather conditions and forecast that benefit the farmers to smartly enhance agriculture production. The monitoring of specific parameters of environment such as temperature, humidity, solid moisture level, etc., is equally important and thus all these sensors need to be included in a whole framework for agriculture and Remote Sensing applications.

A clarification at the end of this section is necessary. In this manuscript, the term “smart” has been used several times, namely smart sensors, smart agriculture, smart farming, etc. This is commonly due to the use of powerful soft computing techniques called as AI techniques. The attempt has been made in bringing out the specific applications of smart sensors in the Remote Sensing field along with challenges and types of sensors used. However, the focus on AI technologies and their detail is not in the scope of this study.

We have also explored the research impact in the proposed field in few more important databases, namely Google Scholar-MDPI, IEEE digital library (IEEE Explore) and ACM digital library. The summary of the research contributions in these databases can be seen in Table 6.

It can be seen that the research impact and quantum of contributions in the area of smart sensors and IoT for agriculture as well as remote sensing applications, is very limited in IEEE database. The research articles reported in IEEE Explore are very specific and noteworthy on remote sensing and agriculture applications. However, the methodologies used; the types of sensors; and the various network architectures are not robust in most of the literature reported. On the other hand, the number of articles and their impact are significantly reported in ACM databases, almost 150 thousand or more in each sub-domain of research on the proposed topic. Similarly, Google Scholar reported sufficient number of research articles in the field of smart sensors used for agriculture and remote-sensing-based usages. An attempt has been made in exploring the contributions separately in MDPI databases, but the keywords used in Table 6 did not result into any literature. However, Google Scholar database literature includes MDPI articles also. An important observation is that the literature reported by Google Scholar and ACM digital library is not focused and includes several inter-related works on remote sensing and agriculture applications, such as image enhancement, image restoration and segmentation. In addition, more focus

was given to the image processing part of the research, rather than on role of sensors and IoT. Therefore, this again infers that a robust framework of IoT and smart sensors needs to be developed for viable applications in remote sensing and smart agriculture.

6. Conclusions

This paper critically reviews the current status of research and studies in the field of IoT and sensors used for Remote Sensing applications and also in precision agriculture. The literature and a critical review of the work in different fields of smart sensors and IoT in terms of their use, characteristics and limitations have been extensively studied and presented. The recommendations and discussion based on the review have been made in addition to the impact analysis of amount of research carried out in recent years in the area of study. A requirement of framework of IoT and robust set of sensors is recommended for efficient Remote Sensing applications and their deployment. Despite the fact that there are a huge number of sensors for various applications, the sensors for Remote Sensing that result in a novel and robust remote sensing based agriculture monitoring and control is quite limited. Moreover, the statistics and their use in various literature are rarely used in the research and thus future work can attempt the statistical analysis and performance evaluation of IoT and sensors for the cited applications. Specific work on robustness, selection of sensors, environmental parameters, design of suitable IoT and smart sensors, needs to be carried out in the future.

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