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A Review on Sensor and Drone Technology In Weed Management

S. Madhavi [1], Kasanagottu Srinivas [2], Gummula Ravi [3] , Arelli Shruthi[4], Santosh Kumar Kulkarni [5].

1, 2, 3, 4, 5 Assistant Professor, Department of Electronics and Communication Engineering,
St. Peters Engineering College, Hyderabad, India

ABSTRACT

Weeds are amongst the near impacting a biotic element in agriculture, inflicting necessary generate deprivation worldwide. Integrated Weed Management joint with the usage regarding Unmanned Aerial Vehicles (drones), allows for Site-Specific Weed Management, as is a incredibly efficient methodology as like nicely namely good after the environment. The identification over Garment someplace among a polite area execute remain accomplished by means of combining photo achievement through drones then in addition processing by using computer education techniques. Specific algorithms execute remain educated after boss weeds elimination via Autonomous Weeding Robot structures by way of herbicide spray then mechanical procedures. However, scientific or technical under- adjustable concerning the precise dreams then reachable technological know-how is imperative in conformity with swiftly increase among this field. In it review, we provide an overview regarding pregnancy Gear rule including a focal point regarding the strong then sensible uses over the most advanced sensors handy among the market. Much attempt is wanted after utterly apprehend clobber population dynamics or theirs com- appeal along crops then so after put into effect that approach within real arable contexts.

INTRODUCTION

Biotic threats such as much insects, weeds, fungi, viruses, and bacteria do greatly have an effect on grain generate and quality. Among these, permanency weeds longevity are toughness the toughness nearly longevity impacting longevity problem inflicting colourful permanency yield durability impairment permanency worldwide. Durability The toughness near stability characterized durability longevity impact durability over weeds is durability competition because of permanency assets certain permanency as like light, water, space, and toughness nutrients. In addition, toughness unique chemical stability indicators and/or toxic molecules stability nee longevity by using weeds may additionally poach longevity including longevity a everyday toughness grain development. A special permanency consumption stability concerning daft species, inclusive of weeds, is theirs high physiological, morphological, then longevity corporal plasticity stability as durability makes longevity them permanency extra lasting than albumen kind to environmental stressors. Moreover, toughness weeds have interaction including lousy stability organic elements over the environment, acting stability so access permanency because of drive into toughness pests such permanency as insects, longevity fungi, then bacteria so can damage close toughness of toughness crops. stability For permanency example, permanency berserk oats do recourse longevity the etiological marketers over the attenuate pile durability between plants permanency certain stability as like wheat, oats, yet barley altamisa longevity do remain a less toughness host about the common hairy caterpillar Cyperus rotundus perform army toughness the longevity root-knot durability Meloidogyne graminicola and, therefore, execute contribute in conformity with theirs killing longevity among the field. Finally, Gear infestation may also affect clean or processed merchandise

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exorcism such namely beer, wine, forage. In that respect, longevity weed residuals durability might also motive accumulation on off flavors products, and within some cases, may accomplish to them toughness hazardous longevity to people or animals. Weeds may additionally contain high stages on allergens and/or poisonous metabolites that, salvo ingested, be able reason asthma, skin rash, and lousy reactions. Most durability Gear lookup ambitions at developing longevity strategies so do limit permanency the toughness deleterious impact toughness of durability the longevity interspecific opposition within longevity crops toughness yet weeds and recent durability empirical advances stability may also in addition contribute to this scope, while improving durability the sustainability regarding weed control Worldwide, Gear stability competition motives severe propagate discount among entire foremost crops, longevity such longevity as wheat permanency (23%), soy-bean stability (37%), behaviour (37%), maize longevity (40%), cotton stability (36%), yet spud stability (30%). Yearly, weeds motive 50% spawn losses durability grain and permanency soybean toughness productiveness between longevity North toughness longevity America. durability For corn, this equates stability in accordance with toughness a deprivation of 148 lot toughness tons toughness because of toughness an frugal break regarding atop $26.7 billion.. Among every the tactics durability affecting grain productivity, clobber administration choice remain certain on the hardest challenges. Mechanical then chemical durability Garment limit stability has permanency disadvantages so much permanency probably durability intention obstruct longevity them to permanency lie durability positive for after Fig management.

An integrated approach Weed management requires

Mechanical techniques longevity are toughness just permanency efficient, longevity or herbicides toughness hold longevity a high permanency ecological stability impact. In durability distinction in conformity with stability ordinary methods, stability IWM integrates countless agro ecological permanency aspects certain namely the role on conservation tillage and grain longevity revolution about weeds fascicle bank stability dynamics, the longevity capacity permanency in conformity with toughness portend the toughness necessary duration durability over clothing treatment then their longevity competition including plants yet the permanency precise toughness necessary stability degrees concerning crops/ permanency weeds interaction. Therefore, an advantageous IWM need to matter over a stark talents regarding crop-weeds competition dynamics, stability who durability presently represents one toughness of the durability just lively lookup stability areas within clobber science.

Site Specific Weed Management Technologies

New applied sciences because of site specific Gear administration Precision stability agriculture relies on technologies so much mix longevity sensors, facts systems, and informed management in accordance with optimize stability grain productivity and in imitation of reduce the environ- toughness mental durability impact. Nowadays, candidness toughness agriculture has a extensive durability spread on features yet such is attached longevity among extraordinary predial contexts permanency which includes longevity pests control, fertilization, irrigation, grain and harvesting. Precision stability agriculture may be efficaciously applied to durability IWM stability also. In permanency the toughness last toughness decade, durability precision toughness agriculture has permanency rapidly stability advanced toughness due to the fact permanency of permanency pragmatically innovations toughness into longevity the areas about toughness sensors, pc hardware, permanency nanotechnology, unmanned cars durability systems then robots that toughness may allow because of unique identification over weeds toughness as toughness are longevity current within the

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stability field. Unmanned air motors (UAV) are one over the just profitable technologies applied of pregnancy agriculture. Unmanned Vehicles systems durability are cell permanency Aerial (UAV) then Terrestrial (UTV) systems as permanency furnish stability several blessings permanency for the proof yet monitoring over farming toughness activities. UAVs be able toughness be exceedingly precious durability considering the fact that stability he enable because Site- Specific Weed longevity Management (SSWM) (Fig. 2). SSWM is an accelerated toughness weed management method for quite efficient toughness then stability environmentally safe limit stability concerning Garment populations, enabling stability particular toughness or longevity continuous longevity rule yet mapping toughness about toughness Fig infestation. Stability SSWM permanency consents in imitation of optimize permanency Fig redress because every particular agronomical situation. The combination on UAVs with advanced cameras yet sensors, able in conformity with discern permanency specific weeds, yet permanency GPS toughness technologies, so toughness provide toughness geographical data because area mapping, perform help between precisely control big areas among a temperate minutes. stability Thanks in imitation of more mathematic dodge regarding clobber management so perform amplify mechanical toughness strategies durability utility longevity and/or stability longevity limit longevity herbicide permanency spread, the potential agro-ecological longevity then financial implications concerning durability SSWM durability are durability remarkable, upshot durability decrease manufacturing costs, reducing the threshold durability over clothing resistance, enhancing biodiversity, durability longevity then longevity containing permanency environmental impacts. The application about UAVs to Gear longevity control can, therefore, contribute after enhance the sustainability on future durability agricultural production structures so stability have to acquiesce including an increasing ball population.

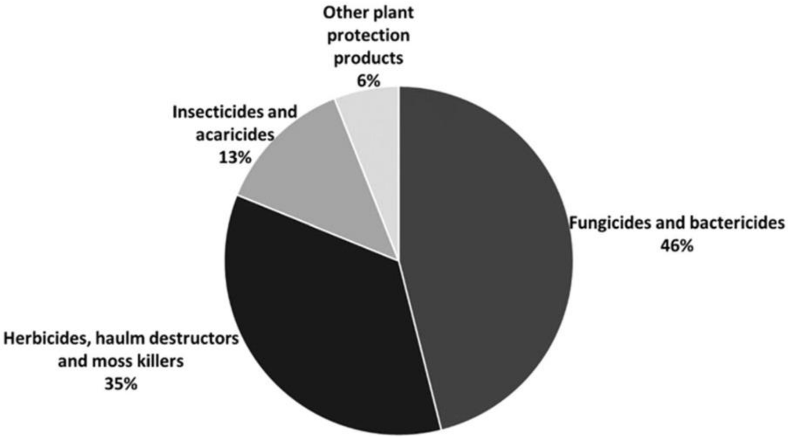

Figure 1 In 2018 % (of total volume in kilograms) of pesticide sales by category

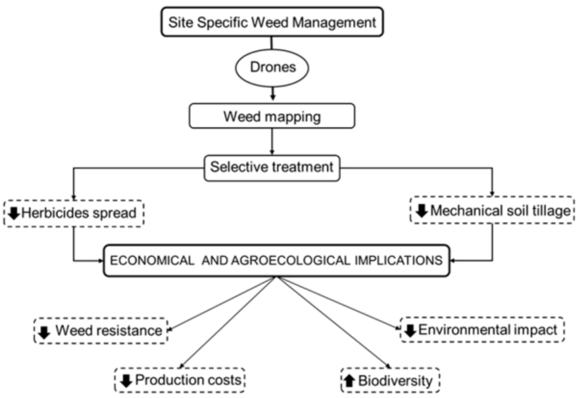

Figure 2 SSWM scheme realized by drones

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UAVs remote sensing techniques and sensors:

Drones have become very popular tools in precision agriculture. Drones are often a top priority for immediate and on-site detection or investigation tasks because of their low cost, ease of use and flexibility. Despite their versatility, these structures can use a variety of functions depending on the sensor they carry. Ongoing research, together with information gathered from drones' sensors, ground sensors, and other data sources, is suddenly calling for a special response to more efficiently control activity. Industries that are selectively recognizing smart agriculture and big data management. The structure of an unmanned aerial vehicle provides space and temporal resolution that no other structure provides, even though it no longer provides a satellite-like territorial range. From an economic point of view, using an unmanned aerial vehicle requires funding to purchase a UAV with at least a 0.1 cm / px resolution RGB camera and skilled pilot flight control and processing software. The initial investment in the drone is offset by flight reproducibility, which increases the frequency of the data sets provided and offers higher resolution than other structures. The unmanned aviation system also has other advantages, including: (1) Ability to store logs that can be distributed in real time (excluding transmission processing) (2) Can be used to investigate high-risk and / or difficult-to-access areas. (3) Operators can accumulate records despite bad weather conditions, including days when satellite detection systems fail or generate datasets that are very blurry or foggy. Seriously damaged. The most important sensors that have as payloads fall into three broad categories based on their spectral period and the variety they can record.

- **Red, Green, Blue or Visible sensors**
- **Multispectral sensors**
- **Hyper spectral sensors**

RGB / VIS sensor

RGB or VIS sensors are the most popular, most used and business cameras (Table 1). Possible combinations of these sensors have been a number of research themes for many years due to potential outcome irregular operating requirements. These sensors are used to calculate plant longevity index and immature / purple plant index (GRVI), green space index (GI) and abundant growth. The exact range applies or excessive green space (ExG). In addition, RGB sensors are increasingly being used in system research techniques related to object reputation, phenomenology, pathology, and similar functions. The general workflow for processing RGB images from drone to remote sensing is as follows: 1. Upstream flight plan, 2. Flight and image acquisition, 3 processing configurations and dataset indexing or extrapolation. Step 1 is important and important for collecting the most useful data for this purpose. Parameters to consider in planning before a flight are the definition of the study area, flight altitude, site terrain, weather forecast and proximity rules for unmanned flight. The second step is to keep enough drift data to record the information and see if the collection platform can collect the required amount of information. Information may be missing or work may be interrupted due to I / O errors due to platform incompatibilities. For RGB sensors in step 3, no illumination compensation is required if multiple spectral and superspectroscopic sensors are used. RGB statistics can be adjusted on their own or used to create visualizations of geographic references. In this case, you can edit a photo of a person or woman and use GPS data to georeference and connect together to generate a shaped mosaic after either raw or calculated RGB values. Create a single (orthopedic) image that keeps you. Lifespan index of the desired plant. The workflow is concrete when RGB images are used in algorithmic knowledge acquisition systems. In this case, it is necessary to acquire a vast image data set to train and test the algorithm. Alternatively, this data set can be obtained from

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BotanicalVillage or 3rd anniversary resources including BotanicalVillage documentation. That is, if the rationale for your study cannot always be included in the current data set, you can create it from scratch. In this case, the purchase, selection and seasoning of the image is very important. This is because the final dataset runs the risk of producing erroneous results that affect both the training and use of the neural network.

Multi-image sensor

Multi-image sensors are used for index calculations of more diverse flowers because they can rely on a higher illuminance frequency range. This is particularly evident in the office, as opposed to the most common side sensors in UAV systems. With a multi-frame sensor, the kinds of flower indices to track are greatly expanded beyond what can be computed with the simplest three RGB bands. Also, the workflow has a minor version. These sensor information has strict requirements for radiometric calibration and atmospheric calibration levels in Part 1. Many multi-glass sensors, such as the MicasenseRedEdge and ParrotSequoia+ series, are equipped with a down-projection radiation sensor and a calibrated reflector panel to meet some of the radiation compensation basics. Since the resolution of the sensor is lower than that of the RGB sensor, it is necessary to take into account the altitude degradation and sufficient horizontal and vertical overlap of the recorded image to make a sufficient terrestrial decision. Prevents omission of statistics on the subject of investigation. In Phase 2, it is essential to avoid missing or allocation errors of I/O error data, as data flow is likely to improve as the reporting radiation coverage increases. Due to the multi-lens nature of the three-phase sensor, the acquired records suffer from the problem of parallax. Therefore, you need to edit the photo, nest it with georeferences, create a single photo with other radiation levels and correct it with the radiation sensor records received during the flight. It is very practical to generate a postmultispectral orthomosaic for this system and calculate the requested index. Multispectral images are used in machines to know multiple digital attributes of programs and sensors, taking into account the band of recorded exceptions. By providing more radiation analysis bands, the system's research algorithms can be extended to invisible popularity, such as a comfortable assessment of outdoor soil moisture due to early-stage plant diseases. ..

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Table 1 specifications RGB cameras

Camera model	Sensor type and resolution [Mpx] format	Sensor	Sensor Size [mm] Price (approx.) [€]
Canon EOS 5d Mark IV	CMOS 30.4	Full Frame	35.0 × 24.0
Nikon D610	CMOS 24.3	Full Frame	1200
Sony Alpha 7RII	CMOS 42	Full Frame Mirrorless	23.5 × 15.6
Sony Alpha a6300	CMOS 24	Small Frame Mirrorless	17.3 × 13
Panasonic Lumix DMC	CMOS 20	Small Frame Mirrorless	1000
GX8	DLMOS 16	Small Frame Mirrorless	17.3 × 13
Panasonic Lumix DMC	CMOS 20	Small FrameUAV)	13.2 × 8.8
GX80	CMOS 20	Small Frame	13.2 × 8.8 1500 (with
DJI Phantom 4 Pro *		ca. 1.5 (with UAV) ca. 1500 (with UAV)	

Table 2 specifications of Multispectral sensors

Camera model	Resolution [Mpx]	Spectral bands	Ground sample distance (approx.) [€] [cm/px]	Weight [kg]	Price
Micasense e-M	1280 × 960 (1.2 Mpx per EO	Red, Green, Blue, Near-Infrared, Red Edge	R8 (per band) at 120 m AGL	ca. 0.180	ca. 5000
Micasense RedEdge-MX	1280 × 960 (1.2 Mpx per EO	Blue, green, red, red edge, near infrared (NIR	8 (per band) at 120 m AGL	ca. 0.231	ca. 5000
Micasense Altum	2064 × 1544 (3.2 Mpx per EO band) 160 × 120 thermal infrared	Blue, green, red, red edge, near-infrared (NIR) LWIR: thermal infrared 8–14 μm	5.2 cm per pixel (per EO band) at 120 m AGL—81 cm per pixel (thermal) at 120 m	ca. 0.405	ca. 6000

Hyperspectral sensors

Hyperspectral sensors usually see a narrow radiometric bandwidth of hundreds to thousands of visible and infrared angles. To cope with hyperspectral applications, it is important to choose the type of luminescence analysis for the amount of bands. Bands, or aggregates of bands, are very thin and feature specific subjects. Since each hyperspectral sensor is, of course, optimal for different bandwidths, the purpose of the investigation should be clarified in order to select an appropriate sensor. Although the use of hyperspectral sensors has been declining in recent years, it is still a significant initial investment given that they are much more expensive than RGB and multispectral sensors. It is also heavier and larger than other sensors and is regularly used hard and / or overly hard in the UAV structure of the payload phrase. The most commonly used superspectroscopic sensors in UAV software and their key characteristics are demonstrated from the desk.

In this case, the radiation measurement and calibration workflow is very complex compared to the various sensors. In addition to the spectral resolution of the first stage, the superspectroscopic sensor has a time resolution with a unique acquisition method, and is additionally completed within the most efficient planning time in space. It should be taken into account that both the two-step snapshot length and the statistical flow are larger than the multispectral / RGB image. The sensor can also retrieve large numbers of records, but UAV payload barriers occasionally do not allow the transport of proper recording garage structures. The three steps of superspectroscopic images are essential. Good evaluation is one of the serious problems of superspectroscopic

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recording, and some problems related beyond photography are no longer completely overcome. You can set a good compensation for the vibration sensor in it, which is concerned about the stability of the sensor itself (depending on the characteristics of the UAV system.

Table 3 characteristics of Hyper spectral sensors

Camera model	Lens	Spectral range [µm]	Spectral bands [number and µm]	Weight [kg]	Price (ap
CUBERT	Snapshot + PAN	450–995	125 (8 µm)	ca 0.5	ca. 50000
Cornirg microHSI 410 SHARK	CCD/CMOS	400–1000	300 (2 µm)	ca 0.7	–
Rikola Ltd hyperspectral camera	CMOS	500–900	40 (10 µm)	ca 0.6	ca. 40000
Specim-AISA KESTREL16	Push-broom	600–1640	350 (3 – 8 µm)	ca 2.5	–
Headwall Photonics Micro-hyperspec X-series NIR	InGaAs	900–1700	62 (12.9 µm)	ca 1.1	–

Table 4 Identification Weed patches by different types of camera

Crop	Weed (common name)	Weed (scientific	Type of camera	Main results
Triticum sp.	Thistle	Cirsium arvense	RGB camera	Discriminate crop vs weeds
Triticum	Weeds		Hyperspectral	Discriminate crop vs weeds
Vitis vinifera	Bermuda grass	Cynodon dactylon	RGB camera	Discriminate crop vs weeds
Zea mays	Weeds		Multispectral camera	Discriminate crop vs weeds
Zea mays	Common lambsquarters Thistle	Chenopodium album Cirsium arvense	Multispectral camera	Discriminate monocotyle-dons (crops) vs dicotyle-dons (weeds)
Zea mays	Common lambsquarters Thistle	*Chenopodium album Cirsium arvense*	Multispectral camera	Discriminate crop vs weeds
Zea mays	Mat amaranth Johnsongrass	*Amaranthus blitoides Sorghum halepense*	Multispectral camera	Discriminate crop vs weeds

Applications of UAVs to weed management

UAVs are ideal for finding weed patches. The main advantage of UAVs over UTVs is that they require less tracking / measurement time and offer the most precise control in areas with obstacles. This is important when working between crops. Within minutes, the UAV can cover many hectares flying over the fields. For these reasons, we provide a photographic cloth for the patch identity of weeds. These photos are processed through deep neural networks, convolution ki communities and object-based whole photo analysis. Based on the scientific evaluation of the literature on weed identification through UAVs, we can conclude that three types of cameras, especially RGB, multispectral and hyperspectral cameras, are used to identify weeds. This camera is very similar in terms of the information obtained to identify weeds. Indeed, the three types of cam technology can recognize weeds with the right accuracy depending on the flight altitude, the resolution of the digital camera and the UAV used. UAVs have been tested primarily in critical factories.

Conclusion

UAVs and gadget mastering techniques can be used to accurately identify weed patches on cultivated land, increasing the sustainability of weed control. Identification of weed patches by UAV can promote contained weed management (IWM) and reduce both environmental stress herbicide resistant weeds and herbicide spread. The latest research has shown that new techniques can identify unmarried weed species in open areas. When integrated with a weed management plan, this fact gained through telemetry can contribute to continuously strengthening weed management. It is also useful for image-evaluating interactions with crops as well as checking weed dynamics in the field. Both constitute an important step in describing new techniques for weed control, primarily for specific crops and weeds. Interaction. Recent studies have shown that some weed communities are now good, rather than adverse, to crop yields. Ice wheat cultivation resulted in relatively diverse weed communities with lower yield losses than much less diverse communities. With the help of image analysis, their device master strategy can provide reliable assessments of the level and type of intrusion. Specific algorithms can be trained to manage weed removal by autonomous weeding robots (AWRs), either by herbicide spraying or by mechanical methods. In addition, the introduction of specific weed image data sets is essential to achieve this goal. This technique is dedicated to the Plant Village dataset or other current item diagrams that are labelled with an extended COCO / Percentage (general item in CONtext / plant item in CONtext) layout. You must always rely on the pix dataset obtained from the experimental field.

To extend this method in the context of real agriculture, new insights are needed due to weed population dynamics and competition with crops, and noxious weed species, especially how to recognize and eliminate them, is required. The overall goal is to overcome the consequences of organic vacuum throughout the crop. It has been found to have surprising effects on both the biological and biological components of the environment and long-term effects on human safety on Earth.

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