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LEGION BASED WEED EXTRACTION FROM UAV IMAGERY

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Multispectral images are the types of images which consist of many different bands of data for further processing. Vegetation Indexing has Different bands which are combined in the multispectral images and are used to accentuate the vegetated areas. In this one combination is most commonly used LIKE Ratio Vegetation Indexing (RVI). But using UAV imagery this problem has been solved because in UAV the area covered or captured by the cameras would be very wide so that the whole plot or crop can be viewed or captured from the UAV imagery. Legion is a Model used to do Scene Analysis Task, Image Segmentation, Object Selection and Speech Segregation. In this Research work we used the Legion Network approach to Detect or Segregate the Unwanted Crops or Weed to increase the crop productivity by Detecting or Segregating the Unwanted Crops or Weed. We used UAVDJI Phantom 4 having RGB Sensor and Tetracam NIR Sensor to collect the data set. Then we used ImageJ and MATLAB for applying Legion Model algorithm to process and analyze the multidimensional images using linear differential equations which solves the correlation problem of synchronization and Segregation of UAV based crop images to Detect the Unwanted crops.

Keywords: Legion Network, Image Segmentation, Ratio Vegetation Indexing, Multidimensional Images.

INTRODUCTION

Every Country's Progress is mostly depending on the Agriculture growth or productivity. Now a day's agriculture plays a very important role in the economy of every country of the world. So, for this reason precision agriculture field is introduced (Buayuai *et al.,* 2017). This is New field in which first time introduced the use and advantages of information technology in the field of farming and crop growth Smart Farming concept can be introduced. In Precision Agriculture many different techniques and many algorithmic approaches used to increase the crop productivity of any country the main purpose to use the IT in the Farming is also to increase the crop productivity (Mandal *et al.,*2014). So, for this reason many algorithms and designs are used like early weed i-e unwanted crop detection in any crop, crop modeling, vegetation indexing, pest detection many more these are all approaches of Smart farming to increase the crop Yield of any country (Cantelli *et al.,* 2013). In future the need of the food is increased day by day so to manage the whole world food discover new ways and methods to increase the yield of crop so for this reason the precision agriculture field is very important step to discover new ways to increase crop yield like smart farming (Weis *et al.,* 2009) using smart farming as a result many advantages can be achieved like time management, reduce the water and chemical used early pest detect and weed detection so we can increase the crop yield productivity (Li *et al.,* 2011; Quiles *et al.,* 2011; Quiles *et al.,* 2011). So Now UAV based Crop Detection and Weed Detection is very important step in this regard. UAV (Unmanned Aerial Vehicle) is the type of drone which fly over the Crops on different heights and take images of crops from different aspects and different heights (Grichuk *et al.,* 2011). These images are processed for the future detection and segregation or Modeling of the Crops (Sa *et al.,*2018; Brik *et al.,* 2011). In the Field there are some very hard places or environment occurs where UGV is working to assist the human operator because there is a very difficult task or work for human operator to operate on the very large fields so for this reason in the previous few decades Unmanned Ground Vehicle is used for SMART FARMING (Tang *et al.,* 2016; Wang *et al.,* 1999). However instead of the many advantages of the UGV System but this is not a good strategy considered now a days Recently UAV imagery approach or method is very commonly used in this field it is not only for its high resolution and temporal resolution but also for its ability to obtain or take spectra and special data at the same time (Rao *et al.,* 2016; Ursino *et al.,* 2003). So, in recent days Unmanned Aerial Vehicle (UAV) technology is used in place of the UGV (Girau *et al.,* 2007). One big disadvantage of the UGV system is that in UGV limited view of crops can be obtained or covered from the cameras which is very difficult situation (Pérez-Ortiz *et al.,* 2016). In this regard, this article presents a comprehensive review of applications of unmanned aerial imagery for the management of natural resources (Aravind *et al.,* 2015). In particular, we focus on image-based processes; we also describe the present state of applications. of unmanned aerial imagery, including the challenges and future opportunities (*Peña et al.,* 2013; Ishida *et al.,* 2018; Wang et al. 2015).

1) The end application was directly related to the management of agriculture and/or the natural environment.
2) It proposed and evaluated a chain of automatic image-based processes to meet the application-related objectives.

As we know the LEGION Model used in this research to detect the weed unwanted crops is purely based on the oscillatory correlation theory (Paikekari *et al.,* 2016). There are many types of solvers which are used in the MATLAB to solve the differential equations (Saleem *et al.,* 2015). Ode51, ode 45 are the most important two functions which are used (Burgos-Artizzu *et al.,* 2011; Samseemoung *et al.,* 2012). Now the theory is that make one global inhibitor which is used in this model for the purpose of desynchronizations (Vibhute *et al.,* 2012). In next step make the local inhibitors which is based on the local features of the objects and established the connections between different local inhibitors Sankaran *et al.,* 2015). Every local inhibitor is connected with three other local inhibitors to make the network (Hung *et al.,* 2014). For this reason, this model is also called oscillatory correlation network model (Chen *et al.,* 2014; Erena *et al.,* 2016). As we know the LEGION Model is the mathematical model which are based on the Linear single order Differential equations in MATLAB these equations are solved by the functions which are called solver functions we used ODE45 functions in general to solve any kind of differential equations (Pena *et al.,* 2015). ODE means Ordinary Differential equations (Matese *et al.,* 2015). The main questions is that for which purpose Ordinary Differential equations are used in LEGION model (Louargant *et al.,* 2017). There are two types of images used in this process one is gray and other is colored (Peña *et al.,* 2015). In Gray images there is no luminance effect and no color information. In the other hand the information or characteristics of plants and weeds are required and processed the image of any crop accurately then convert the colored images into gray images (Hernandez *et al.,* 2015). When image is converted into gray scale the image is in the the binary form so the segmentations of weed and background is very easy (Zhang *et al.,* 2012). After converting image into gray scale many types of noise like dummy white pixels, plants shadows which can affect the accuracy of processing of images (Zongjian *et al.,* 2008). So, for this reason noise reduction or removal of the noise is very important for the further processing of the images. So, for noise reduction different techniques can be used in this scenario used the Gaussian noise reduction (Peña *et al.,* 2013).

we focus on a related but slightly different phenomenon: the emergence of commercial drones. These drones are designed, built and used by individuals, businesses, and organizations. Though commercial drones owe much of their development to their military counterparts, most designs do not resemble the larger and more expensive surveillance drones (Cantelli *et al.,* 2013). The purpose of segmenting the image into plant and background pixels is to detect the amount of plant material within a specific area. If the amount of plant material reaches a specific threshold, that area is targeted for herbicidal spay application (Ishida *et al.,* 2018). The percentage of greenness, weeds and the normalized difference vegetation index (NDVI) were obtained at different altitudes and compared for their relative performance. In the low-dynamic mode of image data acquisition (tractor driven crane-attachment), the tractor speed was maintained constant and low to avoid excessive jerks during image acquisition. In the high-dynamic mode of image data acquisition (helicopter-mounted platform), a commercially available unmanned helicopter was selected. The helicopter weighed approximately 6 kg with a payload capacity of 5 kg and was flown by a skilled Person with a radio transmitter functioning at a frequency of 42 MHz and with a range of 1–2 km radius (Mandal *et al.,* 2014).The spatial distribution of weeds has often been ignored in weed management because the techniques for measuring the spatial variation of weeds have so far not been implemented. Nevertheless, there is a general agreement that herbicide use can be reduced significantly when applied site specifically. The majority of farmers still need to spray herbicides uniformly across the field, due to the lack of technology for automatic weed sampling techniques and site-specific application technology (Louargant *et al.,* 2017). A major step towards a practical solution for site-specific weed management is the development of precise and powerful sampling techniques to automatically and continuously determine in-field variation of crop cover and weed seedling populations (Hernandez *et al.,* 2015).

MATERIALS AND METHODS

In this Research I am using the LEGION Model to segregate and detect the weed and crop patches from the field images. Legion is basically the Mathematical Model this Model is oscillatory correlation network model this means the whole working of this model is based on the oscillations or phases. This Complete name of this model is Locally Excitatory Globally Inhibitory Oscillatory Network Model. As we know this is Oscillatory Network Model So the smallest unit of this model is Oscillator. As we know the crucial or the difficult step in the segmentation process is to be grouping of similar features and dissimilar features. Legion is a simple Mathematical model based on the two simple first order linear Differential Equations So in legion model to get the results apply these equations on the complete dataset or images to take better results. This Model is basically used at the places where phases synchronization and desynchronization of phases occur to detect different objects. As we know every object which can be detected is detect based on their features because the features of every object are unique. So, in this model same steps are followed but in the form of oscillations.

***Legion Model Equations*:**

As we know the Legion Model is a mathematical model based on the first order linear differential equations which solves the correlation problem. So there two main equations which are involved in the process of synchronization and desynchronization. These two equations are the first order differential equations. And We also know these equations are the main equations of the LEGION Model the whole theory is based on these two differential equations. This model is based upon mathematical relationship. LEGION Model is based on single oscillator for i simple form of oscillator and loop between the excitatory unit xi and inhibitory unit yi. As it can be represented with following Eq. (1) and Eq. (2) first order differential equations.

$$\frac{dx_i}{dt} = 3x_i - x_i^2 + 2 - y_i + \rho + I_i + S_i \qquad \text{Eq. (1)}$$

$$\frac{dy_i}{dt} = \epsilon[\gamma\left(1 + \tanh\left(\frac{x_i}{\beta}\right)\right) - y_i] \qquad \text{Eq. (2)}$$

As in these two equations different parameters are used and know we explain these parameters or effect of these parameters on the model. I_i represents the external stimulus and ρ represents the amplitude of the guassian noise term. If the amplitude of noise is greater the results are affected. Si represents the coupling term of the different oscillators in the network. The noise is included in every system and also guassian noise is added to measure the robustness of the system. The Most important property of any DRONE technology is the flight time of the drone which is a distinct quality of every drone. The Flight time of every model of drone is different and the drone technology of drone is that in which flight time are increased. The Flight time is taken or count when the Drone is taken off. So, the requirements of flight time is changes from domain to domain. In Agriculture field the flight time of the drone should be minimum 20 minutes to capture crops images. So phantom 4 pro is the model which provides all the properties which are necessary for the domain of agriculture including the flight time. The Flight time of phantom 4 pro model (Saqib *et al.,* 2018) is very good and effective explained in table 1.

Figure 1. Phantom DJI 4 UAV (Pérez-Ortiz *et al.*, 2016)

DJi phantom 4 pro is the latest model previous models of like phantom 3, phantom 2 and many others are also used in this field the flight timing of every model is different. So, we know the average flight time required in the field of agriculture for capturing images is 20 minutes. So the flight time of previous versions of the Phantom DJI Series like phantom 4 and phantom 3 is very low Like 18 and 20 minutes but the flight time of the phantom 5 Quad copter DJI is very best 22 minutes of flight is normal range of this type of Drone (Saqib *et al.,* 2018). So as compare to other models the flight time of this model is best and the other best thing is that there are separate batteries are provided with device these batteries are rechargeable.

Figure 2. Rechargeable battery of DJI Phantom 4 UAV (Ishida *et al.*, 2018)

Table 1. Specifications of DJI Phantom 4 Quadcopter.

Sr.	Specifications	
1.	Max Flight Time	28 Minutes
2.	Max Speed	S- Mode 20m/s
3.	Altitude Range	0-33 feet (0-10 m)
4.	Image Size	4000 * 3000
5.	Supported SD Card	Max Capacity 64 GB
6.	Battery Capacity	5350mAh
7.	Voltage	17.4 Volt
8.	Max. Weight	1388g
9.	Obstacle Sensing System	Yes (Rang 0.7 to 25 m)
10.	Vedio Output Port	HDMI (Yes)USB (Yes)
11.	Max Ascent Speed	S-mode 5m/s
12.	Max Descent Speed	S-mode 20m/s

There are several tools and software with varying versions specifications those can be used for distinct but similar purpose. Thereof, in this research, following list of tools are being used to develop to manipulate the data at different stages of LEGION algorithm (Saqib *et al.,* 2018).

Table 2. Software's List Used in this Research.

Sr.	Tools/Software	Version	Component/Module
1.	Microsoft Excel		Data Saveing in the form of pixels
2.	MATLAB R2017b	R2017b	Image Processing Toolbox Computer Vision Toolbox Image Acquisition Toolbox
3.	ImageJ	1.52a	Histogram Color Spreads
4.	UAV	DJI Phantom 4	
5.	RGB Sensor	TCS34725	
6.	Tetracam NIR Sensor	230218	

RESULTS

Following code snippet provides the implementation of the LEGION (Saqib *et al.*, 2018) main differential equations in MATLAB. Fig.3 is about function calling in ode45 solver function.

```
global Phi;
global I;
global Rho;
global Eta;
global Gamma;
global Beta;
global Epsilon;
global m;
global n;

% Read Image and show image

 i = imread('newtest.png');
 imshow(i);
 % First Convert the imge into  binary
     g = im2bw(i);
     imshow(g);
     g = im2double(g);
initVec = [g];
initVec = initVec(:);
%initVec(end) = [];
```

Figure 3. Algorithem Listing

Figure 4 is about equation solving in MATLAB (Saqib *et al.*, 2018).

```
I = 0.1;
Rho = 0.1;
Eta = 0.02;
Gamma = 8;
Beta = 0.1;
Epsilon = 0.02;
Phi = 3.0;

T1 = 0;
Tf = 100;
StepSize = 0.1;     %step size may be from 0.1 to 0.01 etc.
refine = 1;
options = odeset('Refine',refine);
[T,Y] = ode45(@LegionODE, [T1:StepSize:Tf], initVec);
figure, plot(Y);
%  plot(Y(:,1),Y(:,2));
```

Figure 4. Algorithem Listing 2

Application of Legion

```
function  dy = LegionODE(t,y)

global m;
global n;
global Epsilon;
global Gamma;
global Beta;
global I;
global Phi;


%global Dweight;
% global Theta;
% global Potential;
global Rho;

m = 95;     %total 187 *2 = 374
n = 84;
dy = zeros((2*(m*n)),1);
dy(1:m*n,1) = (3).*(y(1:m*n,1));
```

Figure 5. LEGION ODE Function

```
m = 95;     %total 187 *2 = 374
n = 84;
dy = zeros((2*(m*n)),1);
dy(1:m*n,1) = (3).*(y(1:m*n,1));
dy(1:m*n,1) = dy(1:m*n,1) - ((y(1:m*n,1)).*(y(1:m*n,1)).*(y(1:m*n,1))) + 2;
dy(1:m*n,1) = dy(1:m*n,1) - (y(m*n+1:2*m*n,1)) + (I(:)) + Rho;
dy(m*n+1:2*m*n,1) = (Epsilon).*((Gamma)*(1+tanh(y(1:m*n,1)*(1/Beta))) - y(m*n+1:2*m*n,1));
%dy(1:m*n,1) = (3).*(y(1:m*n,1)) -((y(1:m*n,1)).*(y(1:m*n,1)).*(y(1:m*n,1))) + 2 - (y(m*n+1:2*m*n+1,1)) + (I(:)) + Rho;

%% My Scafolding code to analyze above variable using loop

% dy_2 = zeros(156, 1);
% dy_2(19,1) = (1+tanh(y(19,1)*(1/Beta)));
%
% return;
% for i = 1:156
%     dy_2(i, 1) = (1+tanh(dy(i,1)*(1/Beta)));
% end

%dy(end+1) = (Phi)*(Zfunc(y(1:m*n,1))-y(end));
```

Figure 6. LEGION Algorithm

As we discuss in previously the LEGION model is basically the rate of change of anything because differential equation is used in that places where rate of change is necessary to find and to in this section first implement the LEGION algorithms on random vector based on initial conditions and not images data just test the LEGION algorithms in Fig.5-6 (Saqib *et al.*, 2018). As we discuss earlier that the LEGION model is basically the rate of change of anything because differential equation is used in that places where rate of change is necessary to find and to in this section first implement the LEGION algorithms on random vector based on initial conditions and not images data just test the LEGION algorithms. As a result, graph is shown in Fig.7 as an output in MATLAB which is given below.

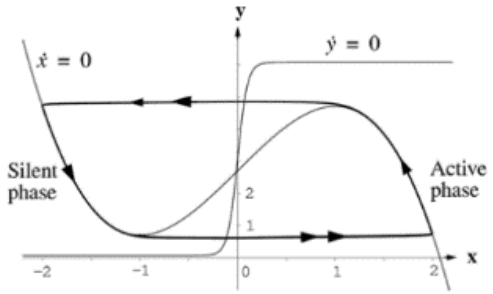

Figure 7. Simple Graph of Legion Model (Girau *et al.*,2007)

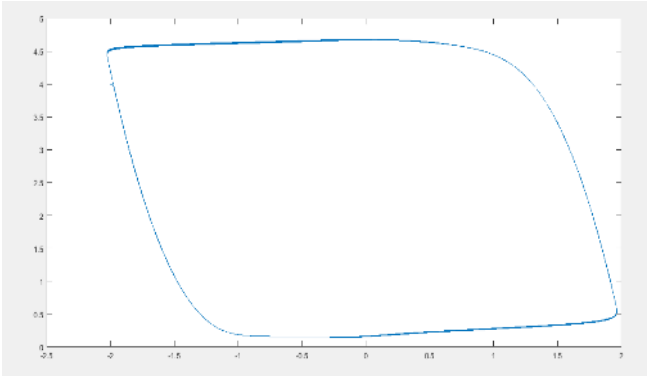

Figure 8. Implemented Legion graph on random initial condition

Fig.8 shows the LEGION model graph and is test on the initial conditions of [-2 4] and the time stamp in this graph is t1 = 0 to tf = 1000 and the step size of every step is 0.001 As discuss in previous chapter try to make the step size small. In this graph (Saqib *et al.*, 2018) two lines are shown downward line shows the silent phase of oscillator at x = 0. And second line which is upward direction represents the Active phase of oscillator at = y =0. These silent phase and active phase are represented in this LEGION model as Desynchronization and Synchronization of objects. As describe earlier that listing the pages Actual LEGION algorithms is applied on the image data set as our actual goal is to detect the weed from images. To apply this on images data the difference is in the Initial conditions pass the image as a parameter in the place of initial condition but first convert the image into binary form and after that convert the whole image into the column vector using function.

cvector = g(:)

in this case g represents the column vector. So just try LEGION model on images first we use the OHIO image which I make in the PAINT the dimension of the OHIO image should be less like 100 * 100 or in my case the dimension is 140 * 114 So apply LEGION on this image data and make the Parameters Values fix LIKE mentioned here.

I = 2.0 The Differential equations solves through the following parameters.

$\epsilon = 0.02$, $\alpha = 5.0$, $\beta = 0.1$, $K = 50$, $\Theta x = -0.5$, $\Theta z = 0.1$ and $\phi = 3.0$

After setting these parameters pass Image as a data in this LEGION model for image segmentation. So, image size should be small because the large image data is taking more time to solve the problem so first time take small input for time the purpose of time and memory consuming. Convert this Image into binary form and after that work on this image. The dimension of the image is 140 * 114 means the column vectors which are made is 15960 and 15960 times equations are solved for each pixels value after every step size the values are changed. The step size which I made is T1 = 1 and TF = 100 and step size remains 0.1 So the Total vector which is make after evaluation is 1001 * 15960 Means 15960 vectors include in this output for 1001 times. And after that Convert the Vector dimensions in to columns and rows means take transpose of these vector because every 15960 columns vectors against one time produced an image. And after that take one Columns vector as a data and save it in the Excel software to save on computer. And After saving of dataset import these datasets in MATLAB in the form of Matrix Because this is in Vector form so convert the vectors back into the image form and the dimension of image should be 140*114. So, for converting I used the reshape function of the MATLAB. And after reshaping into the image dimension Like 140*114 then write the image in a folder as a JPEG or PNG format Fig. 8-10 (Saqib *et al.*, 2018). So, repeat these processes for the 1000 vectors which includes 15960 rows in every column. For reshaping used the code as given below i = reshape (dataset, [140,114]). And for the writing the image in the folder the code in the MATLAB given below.

```
Write(i,'1.jpg','JPEG')
Write (i,'1.png','PNG')
```

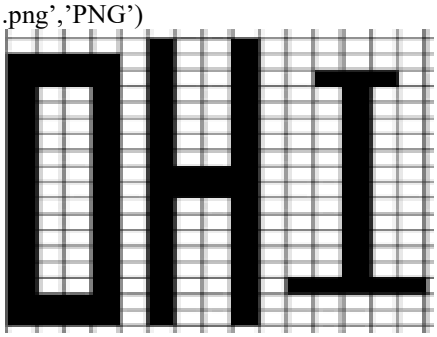

Figure 9. Simple word OHI image for test

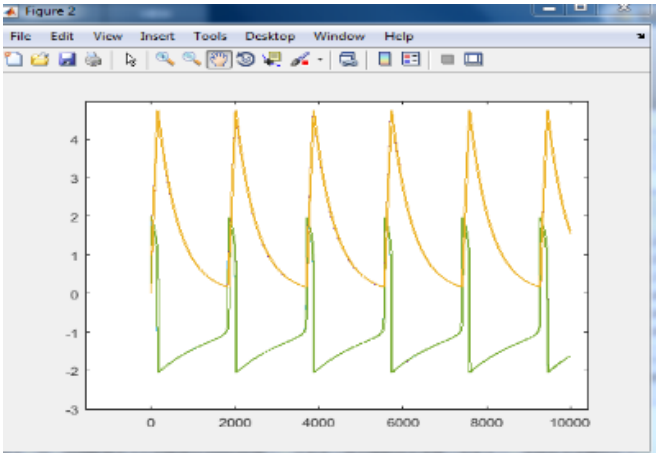

Figure 10. Phases Output

So, in final the output is like this, but this is not actual and accurate output. So, this is the basic output which get and discuss here. In this output just try the LEGION model in the simple OHI image which make in photoshop and the dimension of this image is 140* 114. As we know the images are produced in every Column vector and this is representing the images which we required. As in this image OHI is recognized in Every Column at a Proper place and all other words are removed. Now the next step of this research work is to apply this LEGION model on the real images which we captured to segregate or detect the Weeds from the crop image. As we know the dimension of the Original image of field which I used is 4000*3000 and the total column vector of image is comprised over the 12,000,000 which is very large data used for the purpose of detection so to solve the issue of out of memory actually we clear the memory of previous vector and again write the next column vector which produced the image against this column vector so this is the strategy which used to solve the out memory error arises. I cropped the

image to reduce the size of image and Now the dimension of image is 800 * 575 and we know that convert this into the column vector for Applying Legion Model after converting 460000 values are in single column vector.

Figure 11. Original Cropped image of weed.

So, for this reason images used are shown in the fig. 11-14 (Saqib *et al.*, 2018). This is image Now apply the LEGION Model on this image to detect the Weed rows in the field so for this reason same process which I applied on the simple image also apply on this image but in this Scenario the image size is very large so for this reason 460000 * 1000 data are achieved which is very large for a simple Computer so the Memory Management is very important in this scenario the use of Memory is discussed in the above.

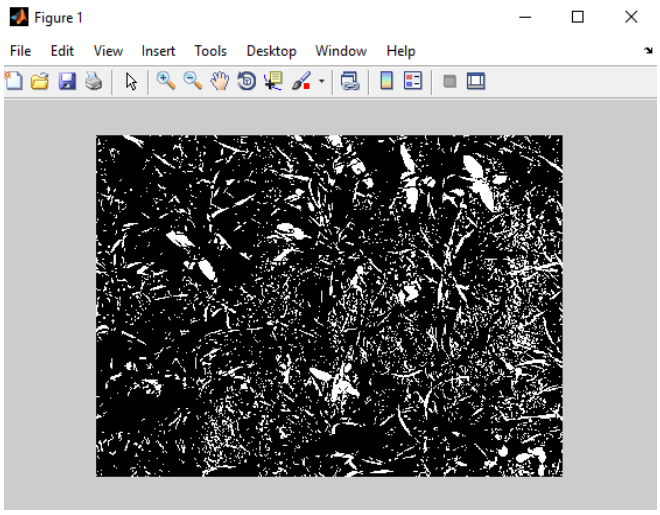

Figure 12. Image in Binary Form.

First of all, use image as a data and convert image data into column vector and convert the image into binary form because LEGION Model is applying on binary form. After converting make the initial condition of this vector and after setting the required parameters which are used in the LEGION Model which is constant Like Gamma, Rho and many more Now call the Legion ode function which basically solves the equations of the LEGION Model to detect the Weed and pass the initial condition of image vector as a parameter in the ode45 function.

Now the dimension of output data after solving is 1000 * 460000 but we required 460000 * 1000 because every single column vector generate a specific image against a single time step. For this take the transpose of this whole output data and save it in another variable. Now the dimension becomes 460000 * 1000 when T1 = 1 and Tf = 100 and step = 0.1. Now to generate the output save the data of Every column vector in the form of excel sheet and after that import into MATLAB using import command as matrix and the column vector size in this scenario is 460000 * 1. Then after importing reshape the column vector back into the image dimension Like 800 * 575 for reshaping use the reshape command of MATLAB which is discussed in previous page. And then Last step is that write the data into the image form and save the image into the folder to see the output.

Figure 13. Image at 1st Time Step after reshaping.

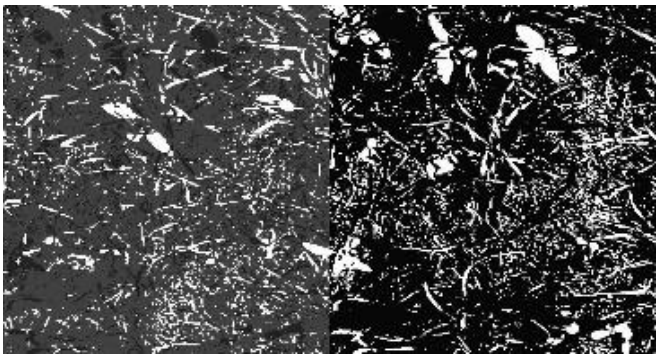

Figure 14. Image Produced at 2nd Time Step after reshaping.

These are Results which are collected after applying the LEGION Model on Real Crop images. So, in these images clearly see that Weeds Unwanted crops are detected through many steps. And note down these results are based on the 0.1-

time step and Time range from 0 to 100. So, 1000 different images produced. The Accuracy of Weed Detection is depending upon the Time Step you want to select. If the time step is small, then accuracy would be increased Like 0.01

***Conclusion*:** For humans to identify the Objects in an images and visual scene I not any difficult task from different patterns of images to recognize the similar objects in an image. Because Human eye and visual system is very powerful for differentiating different objects in an image. Human can recognize every object in an image taking from different patterns. But Human made machines or Robots are not able to identify the objects in different images from different patterns. So, to overcome this issue many computers based artificial algorithms are developed to detect the objects in an image. In Legion Network the basic Unit is Neural oscillators which represent the one unit or object. Connectivity between different Oscillators in Legion Consists of Excitation between locally bounded oscillators and comparison of these locally connected oscillators with Global Inhibited Features (Globally Inhibitor). After Comparison as a Result Legion Model can achieve the Synchronization between the locally connected oscillators Group and Desynchronize between different phases Oscillators Group. In this Research Area we use this Model for Segregation of UAV based crop images to Detect the Unwanted crops. In Legion Network Model Feature of an Objects is grouped i-e same pixels grouped into visual object and after that these same features Objects are segregated from other objects based on Oscillatory Correlation. In this Model an Object has a Single Phase and represent the Oscillators and more than one Object has different Phases and represent Different Phases. Legion Network is not same to other Neural Networks Because in Legion Network the basic Unit is Neural oscillators which represent the one unit. In these algorithms the basic step is to divide the image into small pieces or multiple segments and in second step we can detect the objects in an image.

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