

SpSeg

Species Segregator

User's Guide

"SpSeg" (short for Species Segregator) is a tool for species-level segregation of camera-trap images originating from wildlife census and studies comprising various machine-learning models. SpSeg is currently trained for the Central Indian landscape specifically. This user manual provides details on how to use the tool effectively.



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

SpSeg

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Version 1.0

Last updated: 3rd October 2022

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Check for the new version of the tools and this manual at
<https://github.com/bhlab/SpSeg>



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And, don't forget to cite MegaDetector (without which SpSeg won't even exist):

Beery, Sara; Morris, Dan; and Yang, Siyu (2019). Efficient Pipeline for Camera Trap Image Review. arXiv preprint arXiv:1907.06772

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The problem of camera-trap data sorting

Biodiversity conservation is often challenged by the lack of information on species presence and their populations. Scientific methods to obtain such information are time-consuming not only during field surveys but also during data processing, thus delaying the decision making. Auto-triggered camera-traps to detect the wildlife species have become a popular tool for remote wildlife monitoring. However, segregation of the animal images out of millions of images generated in camera-trapping exercises and tagging those with species identification remains a daunting task.

With the modern advancement in technology, several Artificial Intelligence (AI) based tools have come to the rescue. Microsoft AI for Earth team's [MegaDetector](#) is one such solution developed by Microsoft AI for Earth team ([Beery et al. 2019](#)).

"The approach here is to first classify the images into Animal, Person, Vehicle and Blank, followed by second level classification of animal images into useful taxonomic classes."

 Check out this detailed overview of the approach in a [Medium article](#) and an [explainer](#) by [Dan Morris](#) on why this two-step process.

Microsoft AI for Earth team's [MegaClassifier](#) model was an effort towards second level of classification. However, global models of species classification may not perform well for site-specific dataset due to high morphological confusion among closely related species. For example, the latest global MegaClassifier 'v0.1_efficientnet-b3' model resulted in only 15.95% for the Central Indian Landscape datasets during our testing. High inaccuracy of global models for landscape-specific data required the development of models fine-tuned for the landscape and species.

SpSeg: A solution we bring out

SpSeg is abbreviation for 'Species Segregator', a set of models and tools that [we](#) have developed for species-level classification of camera-trap images at the [Wildlife Institute of India](#), Dehradun, India. SpSeg currently works for the data from Central Indian Landscape, which is the Deccan Plateau part of Madhya Pradesh, Chattisgarh and Maharashtra.

We initially trained different CNN architecture models from [keras](#) (see the [results](#)). We found two models performing well - [SpSeg_x.hdf5](#) and [SpSeg_r152v2.hdf5](#) - and have tested those on various field datasets. [SpSeg_x.hdf5](#) is an Xception model that achieved 88.9% test accuracy, and [SpSeg_r152v2.hdf5](#) is a ResNet152v2 model that achieved 89.2% test accuracy. Find the models from a publicly shared [SpSeg Models](#) Google Drive folder.

Training dataset

SpSeg models can currently segregate [36 commonly encountered species](#) (or taxonomic class) in camera-trap surveys in the Eastern Vidarbha Landscape, Maharashtra, India.

Check our [GitHub repo for updates](#) in the species number and wildlife image data.

Species (Scientific name)	Image set	Species (Scientific name)	Image set
00_barking_deer (<i>Muntiacus muntjak</i>)	7920	18_langur (<i>Semnopithecus entellus</i>)	12913
01_birds (Excluding fowls)	2005	19_leopard (<i>Panthera pardus</i>)	7449
02_buffalo (<i>Bubalus bubalis</i>)	7265	20_rhesus_macaque (<i>Macaca mulatta</i>)	5086
03_spotted_deer (<i>Axis axis</i>)	45790	21_nilgai (<i>Boselaphus tragocamelus</i>)	6864
04_four_horned_antelope (<i>Tetracerus quadricornis</i>)	6383	22_palm_squirrel (<i>Funambulus palmarum & Funambulus pennantii</i>)	1854
05_common_palm_civet (<i>Paradoxurus hermaphroditus</i>)	8571	23_indian_peafowl (<i>Pavo cristatus</i>)	10534
06_cow (<i>Bos taurus</i>)	7031	24_ratel (<i>Mellivora capensis</i>)	5751
07_dog (<i>Canis lupus familiaris</i>)	4150	25_rodents (Several mouse, rat, gerbil and vole species)	4992
08_gaur (<i>Bos gaurus</i>)	14646	26_mongooses (<i>Urva edwardsii & Urva smithii</i>)	5716
09_goat (<i>Capra hircus</i>)	3959	27_rusty_spotted_cat (<i>Prionailurus rubiginosus</i>)	1649
10_golden_jackal (<i>Canis aureus</i>)	2189	28_sambar (<i>Rusa unicolor</i>)	28040
11_hare (<i>Lepus nigricollis</i>)	8403	29 Domestic_sheep (<i>Ovis aries</i>)	2891
12_striped_hyena (<i>Hyaena hyaena</i>)	2303	30_sloth_bear (<i>Melursus ursinus</i>)	6348
13_indian_fox (<i>Vulpes bengalensis</i>)	379	31_small_indian_civet (<i>Viverricula indica</i>)	4187
14_indian_pangolin (<i>Manis crassicaudata</i>)	1442	32_tiger (<i>Panthera tigris</i>)	9111
15_indian_porcupine (<i>Hystrix indica</i>)	5090	33_wild_boar (<i>Sus scrofa</i>)	18871
16_jungle_cat (<i>Felis chaus</i>)	4376	34_wild_dog (<i>Cuon alpinus</i>)	7743
17_jungle_fowls (Includes <i>Gallus gallus</i> , <i>Gallus sonneratii</i> & <i>Galloperdix spadicea</i>)	4760	35_indian_wolf (<i>Canis lupus pallipes</i>)	553

A maximum of 5000 images were randomly selected for each species from our [image dataset](#) to train the models. The models were trained with 70% of the selected data, while 15% images were used for validation and remaining 15% were used for testing. Therefore, species with more than 5000 images in our [image dataset](#) have better accuracy, except sexually dimorphic species like Nilgai.

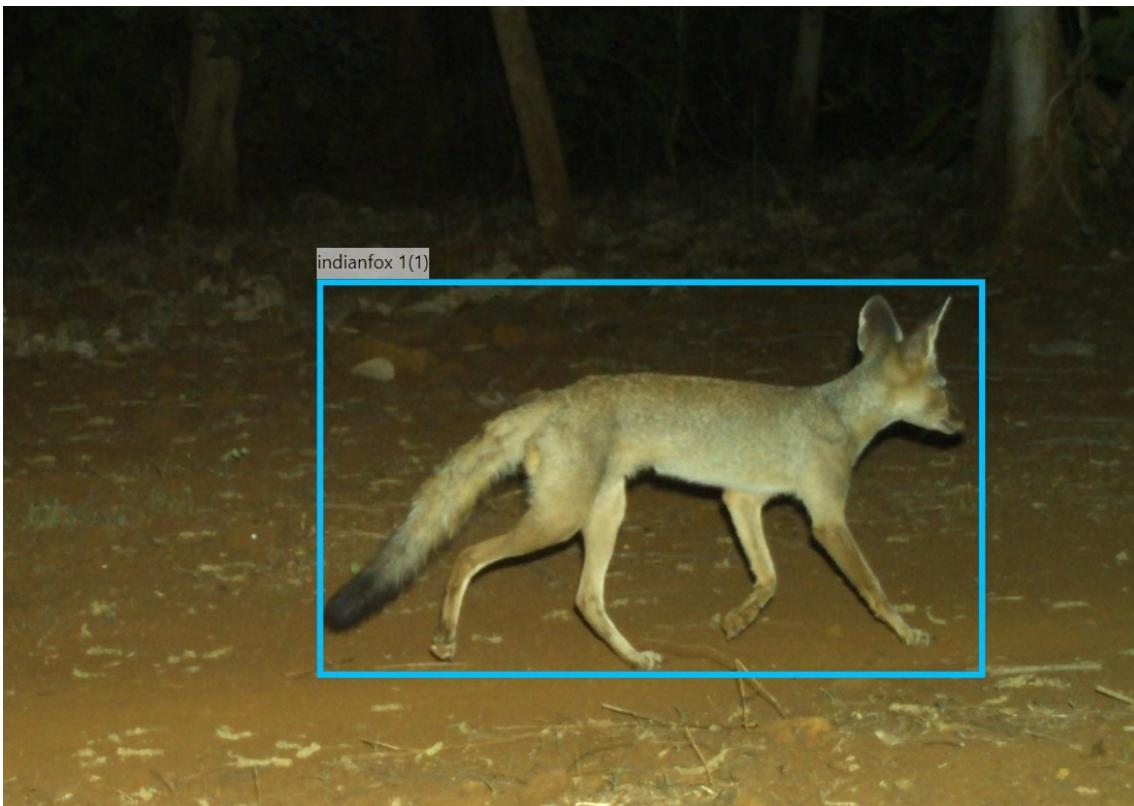
How does it all work?

SpSeg model (either [SpSeg_x.hdf5](#) or [SpSeg_r152v2.hdf5](#)) reads the results of MegaDetector and classifies the animal images into species (or a defined biological taxonomic level). MegaDetector detects **Animal**, **Person** or **Vehicle** in the image and tags it with a bounding box telling exactly where the item is in the image.



MegaDetector detects an animal within a bounding box on an image.

SpSeg models read the information for only **Animal** tags above 0.85 confidence from MegDetector and classifies those up to species level. Therefore, both the models (detector and classifier) are required to run simultaneously on the images.



SpSeg model identifies an Indian fox within the bounding box.

☞ You can find more about how you can run MegaDetector on your images from this official [MegaDetector GitHub page](#).

⚠ Keep in mind that the SpSeg is developed with MDv4. Although MDv5 has been launched, at this moment we recommend to stick with MDv4. We shall integrate SpSeg tools with MDv5 in future updates.

Setting up the tools

We are covering only basic information here. These instructions are quite similar to the [instruction for MegaDetector installation](#), where more details could be found. For technical details check the official websites of the mentioned software.

Step 1. Installation

Download and install [Anaconda](#) (or [Miniconda](#)), which is a software platform enabling to create environments to install machine learning frameworks and python tools. Installing [Git](#) is optional, but recommended to keep your repo updated. If you are using a GPU, you also need to check if you have the latest [NVIDIA drivers](#).

Step 2. Access the detector and classifier models

Download [MegaDetector model v4.1.0](#) and [SpSeg models](#) and keep at an accessible location. These instructions will assume that the models are downloaded to a folder called `c:\spseg_models`.

Step 3. Clone git repo and set Python environment

There is no need to setup a separate MegaDetector environment, which is incorporated in the codes here. We are giving the instructions for Windows machines only, which is expected to work on Linux machines in a similar way. The environment is not tested on Mac.

Open Anaconda Prompt and make sure you have not opened an Anaconda Powershell Prompt or Windows Command Prompt. It should look something like this with the name of environment in the parenthesis:

```
Anaconda Prompt (Miniconda3)
(base) C:\Users\shivam>
```

Run the following commands one by one to download SpSeg repo from GitHub:

```
mkdir c:\git
cd c:\git
git clone https://github.com/bhlab/SpSeg
```

The commands above are suggestions. git command will work at any directory and you can download GitHub wherever you find it convenient. Find more about [git](#).

Alternatively, you can download the SpSeg repo as zip folder from <https://github.com/bhlab/SpSeg> and unzip it to a desired location.

Next, you need to enter where SpSeg repo is located using cd command:

```
cd c:\git\spseg
conda env create --file environment_SpSeg.yml
```

You are all set to run SpSeg! ☺

Camera-Trap image data organization

We assume that your camera-trap data was organized in either of the following directory structures:

```
dataDir/Station
dataDir/Station/Camera
```

The first structure arrives when a single camera was placed at the station, while the second structure arrives when A and B cameras were placed facing each other. The directory before Station ID (**dataDir**) could include site ID, range ID and/or block ID.

Running SpSeg

Next time when you open Anaconda Prompt, first you need to activate SpSeg environment:

```
conda activate SpSeg
```

and then locate the SpSeg tools folder.

```
cd c:\git\spseg\tools
```

Which should look something like this:

```
Administrator: Anaconda Prompt (Miniconda3)
(SpSeg) C:\git\spseg\tools>
```

The main tool to use SpSeg models is `run_spseg.py`

Once you are in the right setup (environment and tools folder), the following command calls detector and classifier models and runs over all the images:

```
python run_spseg.py "C:\spseg_models\md_v4.1.0.pb" "D:\dataDir" --recursive --
spseg_model " C:\spseg_models\SpSeg_r152v2.hdf5" "D:\dataDir\data_output.json"
```

"`D:\dataDir`" is the location (local or on network server) where your organized camera-trap images are stored. You can set the path and name of the output file at "`D:\dataDir\data_output.json`".

The above command returns a `.json` directory for each image with detector tags for animal, person or vehicle, and species tags for animals (both the tags with a confident value).

 The image paths are returned as absolute, which creates mismatches during further processing of the data specially if processing is carried out on a different system. Therefore, the best practice is to get the image paths as relative and keep the output file within image folder.

Relative paths in the output can be returned by setting the flag for it:

```
python run_spseg.py "C:\spseg_models\md_v4.1.0.pb" "C:\dataDir" --recursive --
spseg_model " C:\spseg_models\SpSeg_r152v2.hdf5" "C:\dataDir\data_output.json" --
output_relative_filenames
```

How to use the output to process the images?

AI-tools are not 100% accurate. Therefore, a workflow is required to process the output and correct for the errors. Currently, there are two approaches to process the output and finalize the identification/segregation of the images for further analyses-

1. Using Timelapse to review the images (only for Microsoft Windows systems),
2. Using an Image file manager system like Windows File Explorer, [ExifPro](#), [IrfanView](#) or [FastStone](#).

 **Note:** A third approach of [transferring annotations to the hierarchicalSubject field](#) of XMP data of the image and processing thorough [DigiKam](#) works with the output of MegaDetector only, and shall be soon available for SpSeg output.

Timelapse workflow

Timelapse is an image analyzer and tagging software specifically developed to tag camera-trap images by [Dr. Saul Greenberg](#). It is well integrated with MegaDetector system and is one of the fastest methods we have tested so far. Additional advantage

of Timelapse software is that the data can be exported as spreadsheet after reviewing and correcting. The data from Timelapse can be directly read into R and processed by [camtrapR](#) (the most popular R tool to generate basic reports and input files for further analyses on camera-trap data). We have tested it on multiple datasets. Hence, we highly recommend to use Timelapse to review the images.

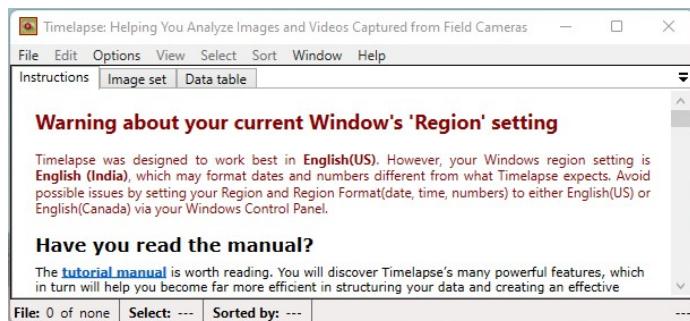
A detailed information on [how to use Timelapse](#) and [how to use image recognition in Timelapse](#) can be found at the [official site of Timelapse](#). Before you start the review, familiarize yourself with the software and its functions (see the [video tutorials](#) for various functions and features of the software).

Here we will cover only the essential steps of the workflow we have implemented to review SpSeg output and tag the images.

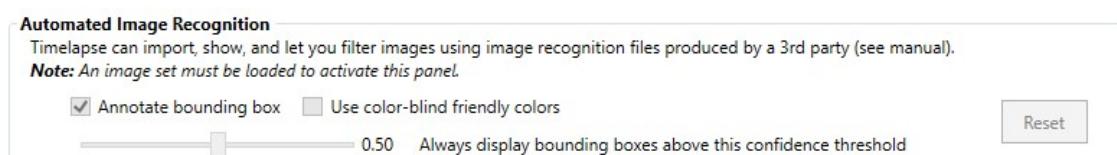
Step 1. Download [Timelapse zip folder](#) and unzip it. You don't need to install it.

Step 2. Copy `Timelapse_SpSeg.tdb` from SpSeg repo folder `C:\git\spseg` to your image data folder `D:\Camera_data` (this `.tdb` file is compatible with Timelapse version 2.3.0.0 and above). Also, make sure that SpSeg output in `.json` file is stored in the same data folder and image paths in the json file are relative.

Step 3. Launch Timelapse software by double-clicking `Timelapse2.exe` in the unzipped Timelapse folder. The opening screen looks something like this:

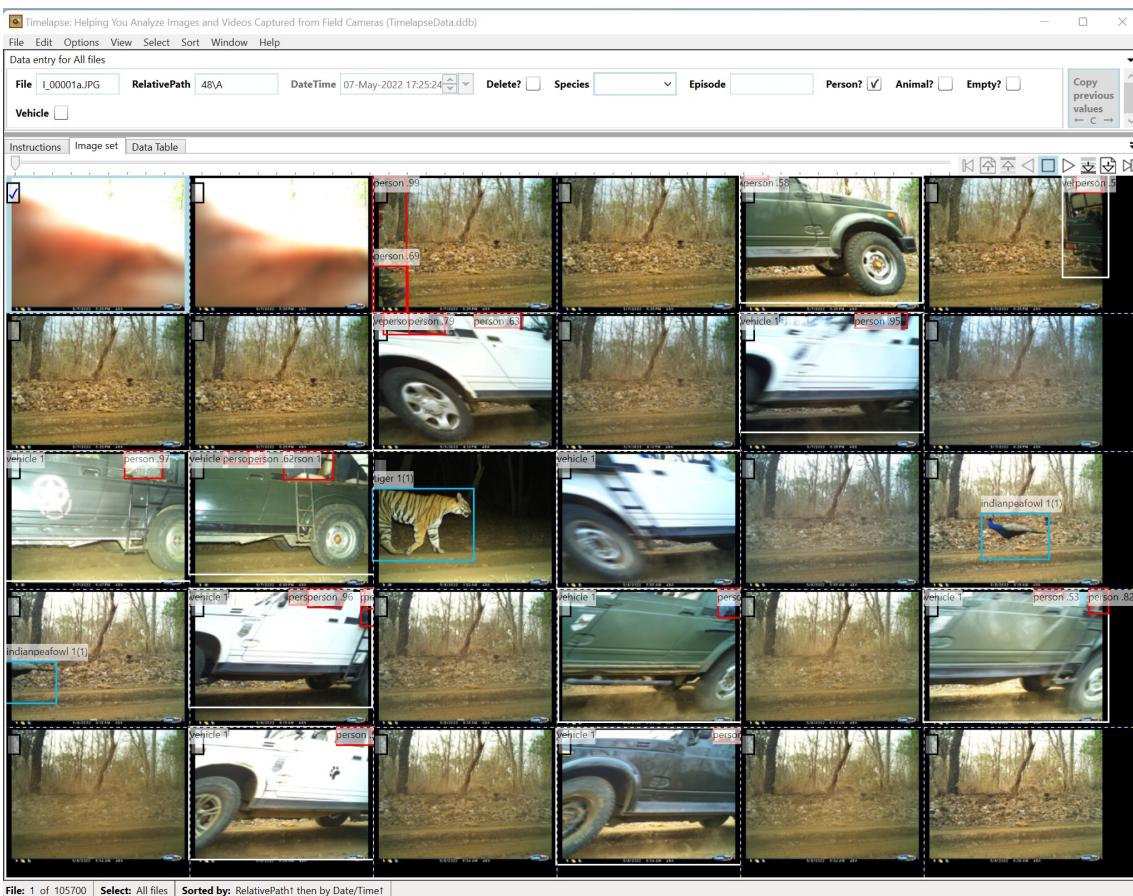


Step 4. To turn on recognition capabilities, select **Option | Preferences** and check the 'Annotate bounding box' and keep the confidence threshold at 0.50:



Step 5. Load the template by selecting **File | Load template, images, and video files...** Navigate to the image directory and select the `Timelapse_SpSeg.tdb` file. Timelapse will take some time to search and load all the images.

Step 6. Import the SpSeg output file by selecting **File|Import image recognition data for this image set**. Navigate to the image directory and select `data_output.json` file. At this point images with auto-detected objects will start showing bounding boxes around the objects.



Step 7. The images can be filtered by AI output using **Image recognition** settings in **Select | Custom Selection**.

Image Recognition

Use recognition Rank by confidence

Recognized entity: **All**

Confidence: from **0.80** to **1.00**

Include all files in an episode when at least one file matches

Step 8. First review all the **Empty** images by setting image recognition to Empty and confidence limit from 1.0 to 1.0 (as the **Empty** images do not have any confidence value).

Image Recognition

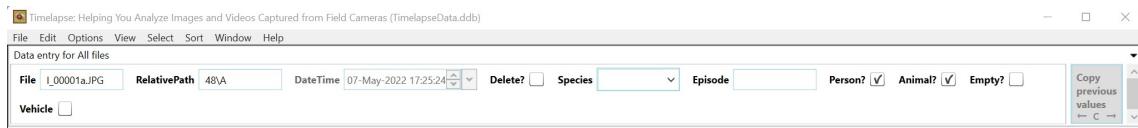
Use recognition Rank by confidence

Recognized entity: **Empty**

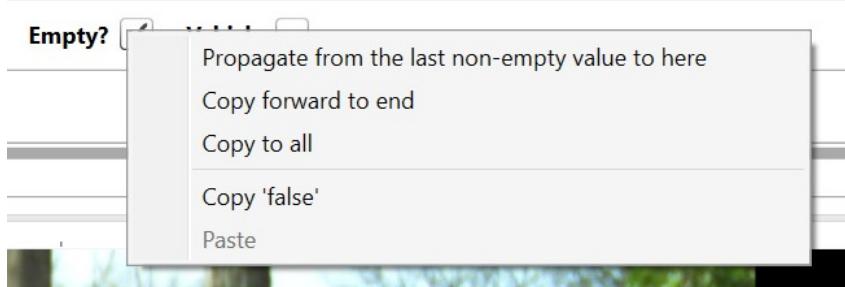
Confidence: from **1.00** to **1.00**

Include all files in an episode when at least one file matches

If an image is not empty, check appropriate flags:



After reviewing, check back the custom selection and omit the images that have been tagged as other than **Empty**. Then tag the remaining confirmed images using 'Copy to all' function by right-clicking Empty flag:



Step 9. Next, review **Person**, **Vehicle** and **Animal** images one tag at a time. You can review these images in two segments. Since images above 0.85 confidence level are usually correct, these can be reviewed at a faster speed, and the image with less than 0.85 confidence level can be reviewed more carefully.

Image Recognition

Use recognition Rank by confidence

Recognized entity: animal

Confidence: from 0.85 to 1.00

Include all files in an episode when at least one file matches

Show only those files the recognizer did not process

11909 files match your query

Select images and videos that match these terms

Select	Label	Expression	Value	How multiple terms are combined
<input type="checkbox"/>	File	=		These terms are combined using AND: returned files match all selected conditions.
<input type="checkbox"/>	Delete?	=		These terms are combined using either <input checked="" type="radio"/> And to match all selected conditions <input type="radio"/> Or to match at least one selected conditions
<input type="checkbox"/>	Species	=		
<input type="checkbox"/>	Episode	=		
<input checked="" type="checkbox"/>	Person?	=		
<input type="checkbox"/>	Animal?	=		
<input checked="" type="checkbox"/>	Empty?	=		
<input checked="" type="checkbox"/>	Vehicle	=		

These selections ensure that an image already tagged with **Empty**, **Person** or **Vehicle** does not appear in **Animal** filter.

Reset to All Images 11909 files match your query Cancel Okay

An image wrongly appearing in a filter or if contains two or more types of objects should be corrected immediately and tagged appropriately.

Step 10. After correcting the tags from MegaDetector, species-level image recognition should be reviewed for only the animal images. Images for a particular species filter

can be selected from the Image Recognition window.

The screenshot shows the 'Image Recognition' interface. At the top left is a checkbox labeled 'Use recognition' which is checked. Next to it is a checkbox 'Rank by confidence' which is unchecked. Below these are dropdown menus for 'Recognized entity' set to 'tiger' and 'Confidence' set from 0.00 to 1.00. A yellow progress bar indicates the search results. To the right is a checkbox 'Show only those files the recognizer did not process' which is unchecked. Below the progress bar is another checkbox 'Include all files in an episode when at least one file matches' which is unchecked. On the right side, it says '234 files match your query'. Below this is a section titled 'Select images and videos that match these terms' with a table of filters. One filter, 'Animal?' with the value 'checked', has a red arrow pointing to it with the text 'This filter ensures that only animal images are selected for species review'. At the bottom are buttons for 'Reset to All Images', '234 files match your query', 'Cancel', and 'Okay'.

Tag a species from Species dropdown menu. All the images in the filter can be tagged to the same species by right-clicking and selecting 'Copy to all' option.

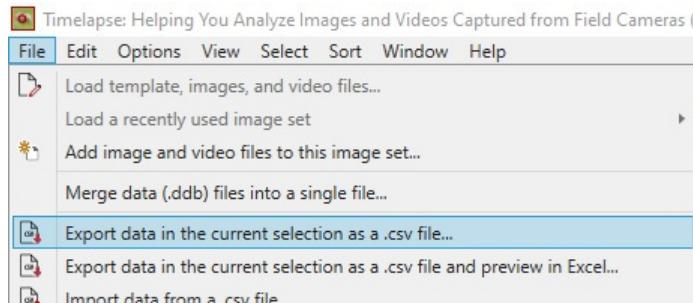
The screenshot shows a detailed view of a tiger's image. Overlaid on the image is a dropdown menu for the 'Species' field. The dropdown is open and shows a list of animal names. The word 'tiger' is highlighted in blue, indicating it is the selected species. Other options in the list include 'indian_pangolin', 'jungle_cat', 'jungle_fowls', 'langur', 'leopard', 'macaque', 'nilgai', 'palm_squirrel', 'indian_peafowl', 'ratel', 'mongooses', 'grey_spotted_cat', 'dassie', 'sheep', 'sloth_bear', 'small_Indian_chiet', 'tiger', 'wild_boar', 'wild_dog', 'indian_wolf', and 'Other'. The dropdown menu has a light gray background and a white border.

Duplicate images: If an image has more than two species, it should be duplicated by clicking on **Edit | Duplicate this record** and each image should be tagged separately.

⚠ Note that selecting **Rank by confidence** option in the *Image Recognition* window excludes duplicate image from current filter. Therefore, avoid using this option.

Step 11. Double check if all the images are reviewed and correctly tagged by unselecting **Image Recognition** and then selecting data filters.

Step 12. Export the data from **File | Export data in the current selection as a .csv file...** option. Clear all the filters and custom selections before exporting the data.



□ An R script **TL2RT.R** is available in the SpSeg folder **C:\git\spseg** to read the .csv output of Timelapse and convert it into *recordTable* format of camtrapR.

Handling large datasets

Sometimes the image dataset is too large and Timelapse stops responding. We observed that datasets above 2,00,000 images often could run into such issues. In such cases, it is advised to split-up the datasets into smaller parts (and the corresponding SpSeg output .json file) for easier handling. In fact, the partitions could be reviewed by multiple reviewers simultaneously.

subset_json_detector_output.py from MegaDetector's [Postprocessing tools](#) splits SpSeg output at defined node in file path. We split the output for top-level folder, which is usually the camera-trap ID. You don't need to download the tool separately. It is included in the SpSeg repo and you can directly run it from the SpSeg environment:

```
python subset_json_detector_output.py D:\Camera_data\Camera_data_output.json  
D:\Camera_data --split_folders --split_folder_mode top
```

The tool will result in separate output .json files for each camera-trap. You can also stitch together these files as per your partition of the data. Let us illustrate this with an example. We had a dataset with 100 camera-traps. We first ran SpSeg model to get single output file. And then split it into 100 smaller files for each trap. Now we divided the entire dataset in two smaller parts of 50 camera-traps each. Hence, we needed to stitch first 50 .json files together and then remaining 50 .json files. We created an empty folder and copied 50 files that we need to stitch together.

merge_json.py tool can read all the .json files in a folder and merge those into a single output:

```
python merge_json.py D:\Camera_data\part1 D:\Camera_data\Camera_data_part1.json
```

First you need to write the path of the folder containing split .json files, and then you need to give a path and name to the output file. In our example, **data_output_part1.json** will contain the information for only first 50 camera-traps.

💡 If a large dataset was processed by splitting into smaller parts, the resulting .csv files for each part can be stitched together by rbind command in R or any other spreadsheet program.

Rearranging raw data after correcting the image identifications

At times the data is needed to be arranged in species level organization, e.g. for individual identification of the tigers and leopards. A tool `sort_spseg.py` can be used to reorganize the raw data using the `.csv` output of Timelapse in multiple ways.

You need to first open Anaconda Prompt and activate SpSeg environment (see [Running SpSeg](#) section).

If you need to export whole data reorganized in species-level folders within camera-trap ID folders for archiving or running camtrapR:

```
python sort_spseg.py D:\dataDir --recursive D:\dataDir\TimelapseData.csv --output_dir  
D:\data_segregated
```

`D:\data_segregated` is a new location where reorganized data will be exported.

Let's export the data for only tigers to process for individual-level identification:

```
python sort_spseg.py D:\dataDir --recursive D:\dataDir\TimelapseData.csv --output_dir  
D:\data_tigers --species tiger
```

You can also export multiple species:

```
python sort_spseg.py D:\dataDir --recursive D:\dataDir\TimelapseData.csv --output_dir  
D:\data_ungulates --species wild_boar nilgai spotted_deer
```

Or you could export all images without blank (empty) images:

```
python sort_spseg.py D:\dataDir --recursive D:\dataDir\TimelapseData.csv --output_dir  
D:\data_detections --exclude blank
```

And if you require only wild animal images:

```
python sort_spseg.py D:\dataDir --recursive D:\dataDir\TimelapseData.csv --output_dir  
D:\data_wild_animals --exclude blank person vehicle dog goat
```

You can custom export by using either `--species` or `--exclude` tag followed by a list of items.

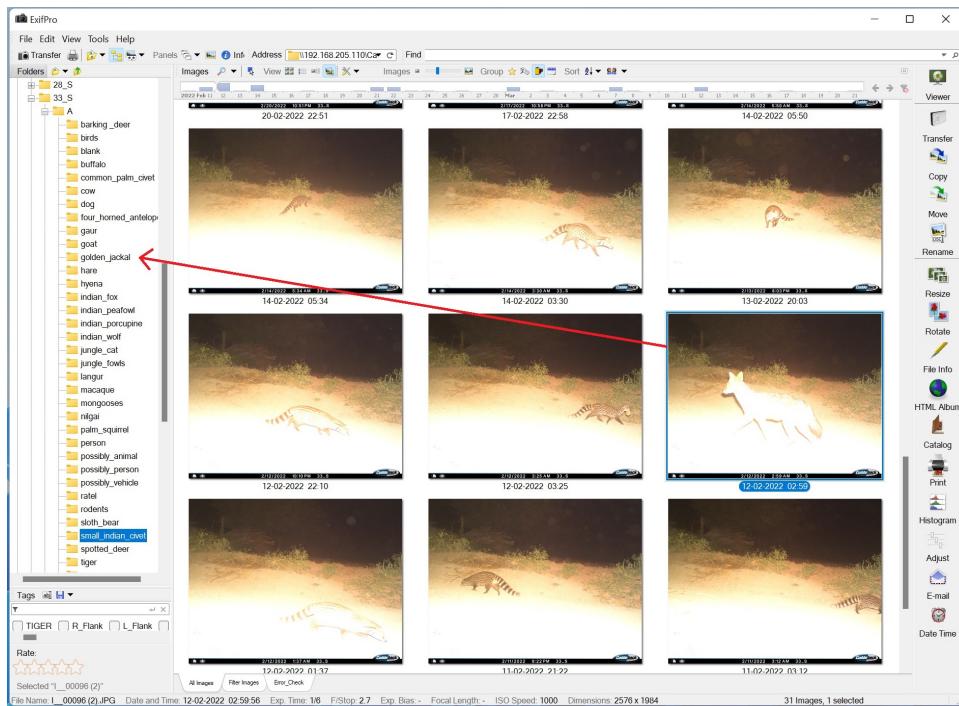
Image file manager workflow

If you wish to use a file manager system (Windows File Explorer, [ExifPro](#), [IrfanView](#) or [FastStone](#)) to review and correct the errors instead of Timelapse, you can export a copy of the data reorganized into species-level folders directly based on the SpSeg output:

```
python sort_spseg.py D:\dataDir --recursive D:\dataDir\data_output.json --output_dir  
D:\data_for_review
```

The tool exports images with <0.85 confidence level (for `Animal`, `Person` or `Vehicle` tags) from MegDetector model to the folders named '`possibly_animal`', '`possibly_person`' and '`possibly_vehicle`' to find inaccuracies easily. Images with a high confidence (>0.85) `Animal` tag are segregated in species-specific folders. Although these images could also have inaccuracies and require a review.

The reviewer can access each folder from programs like ExifPro and move wrongly identified images to correct species folder within the same camera-trap.



Further development

We have in pipeline- 1. integration with MegaDetector version5. 2. developement of DigiKam based workflow, 3. Further refinement of the SpSeg models (particularlylly for dimorphic ungulate species and species with small dataset), and 4. Addition of more species, e.g. we missed out on the elephant in the current models.

So stay tuned!

Also, we would love to hear back from you. If you have any suggestion for additional species or would like to add to training dataset, reach out to us (bh@wii.gov.in) to Participate!

Our Team



Dr Shivam Shrotriya **Venkanna Babu Guthula**



Dr Indranil Mondal **Dr Bilal Habib**

[Dr Shivam Shrotriya](#) is leading and managing this project at the lab and the GitHub repo. He is an ecologist with a PhD on the Himalayan wolf ecology and holds field research experience in the Himalayas and the Central India. Apart from this manual, he tested, edited and partly wrote SpSeg codes.

[Mr Venkanna Babu Guthula](#) is a python developer and machine learning enthusiast, who loves to work on AI-tools for sustainability and nature research. He has been instrumental in developing the codes and training the SpSeg models. He handles the backend of the project.

[Dr Indranil Mondal](#) is a Geographic Information Systems specialist and a technology (hardware/ networking) enthusiast who has played a pivotal role in designing the hardware specifications for this project and is looking at the tool dissemination and adoption by the managers and policymakers

[Dr Bilal Habib](#) is the principle investigator of the this project. SpSeg is develeped and hosted by his lab at the Wildlife Institute of India. He is a wildlife scientist involved in studying population dynamic of large carnivore, their prey and movement ecology at large scale studies in the Central India and the Himalayas. He is a patron of adopting advanced technologies like AI for conservation. Drop an email to bh@wii.gov.in for any querries and/or suggestions regarding SpSeg.

Find us on the web: www.wii.gov.in, <https://bhlab.in/>



SpSeg

Species Segregator

User's Guide

Version 1.0

Last updated: 3rd October 2022

Technical Report No. 2022/29

"SpSeg" (short for Species Segregator) is a tool for species-level segregation of camera-trap images originating from wildlife census and studies comprising various machine-learning models. SpSeg is currently trained for the Central Indian landscape specifically. This user manual provides details on how to use the tool effectively.

Cover Pic: Nayan Khanolkar

Check for the new version of the tools and this manual at
<https://github.com/bhlab/SpSeg>



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