unet Documentation

Release unknown

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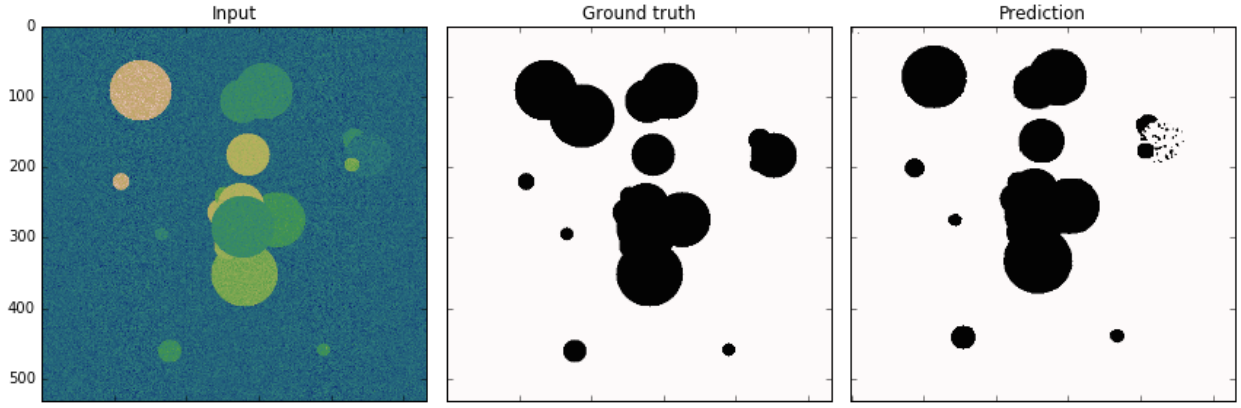
This is a generic **U-Net** implementation as proposed by Ronneberger et al. developed with **Tensorflow 2**. This project is a reimplementation of the original tf_unet.

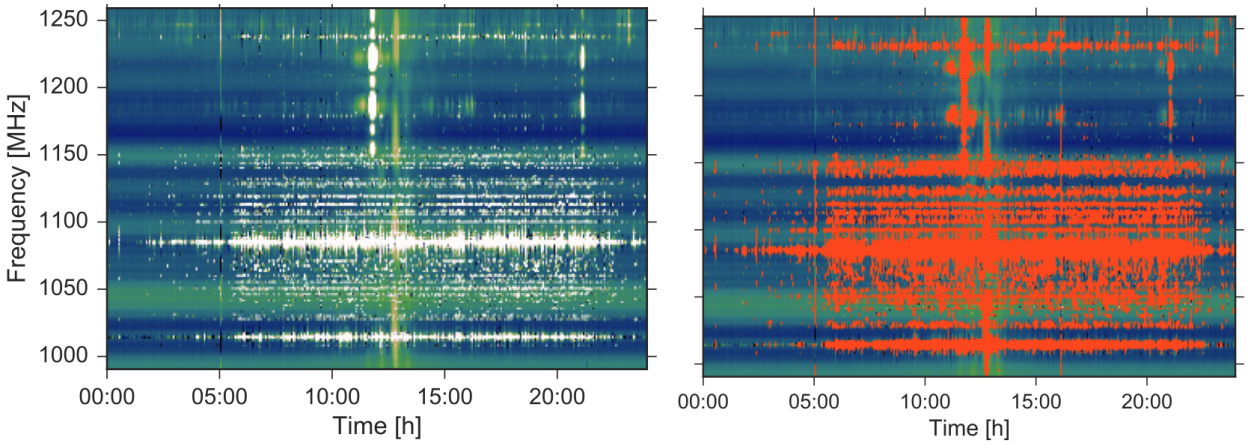
Originally, the code was developed and used for Radio Frequency Interference mitigation using deep convolutional neural networks .

The network can be trained to perform image segmentation on arbitrary imaging data. Checkout the Usage section, the included Jupyter notebooks or on Google Colab for a toy problem or the Oxford Pet Segmentation example available on Google Colab.

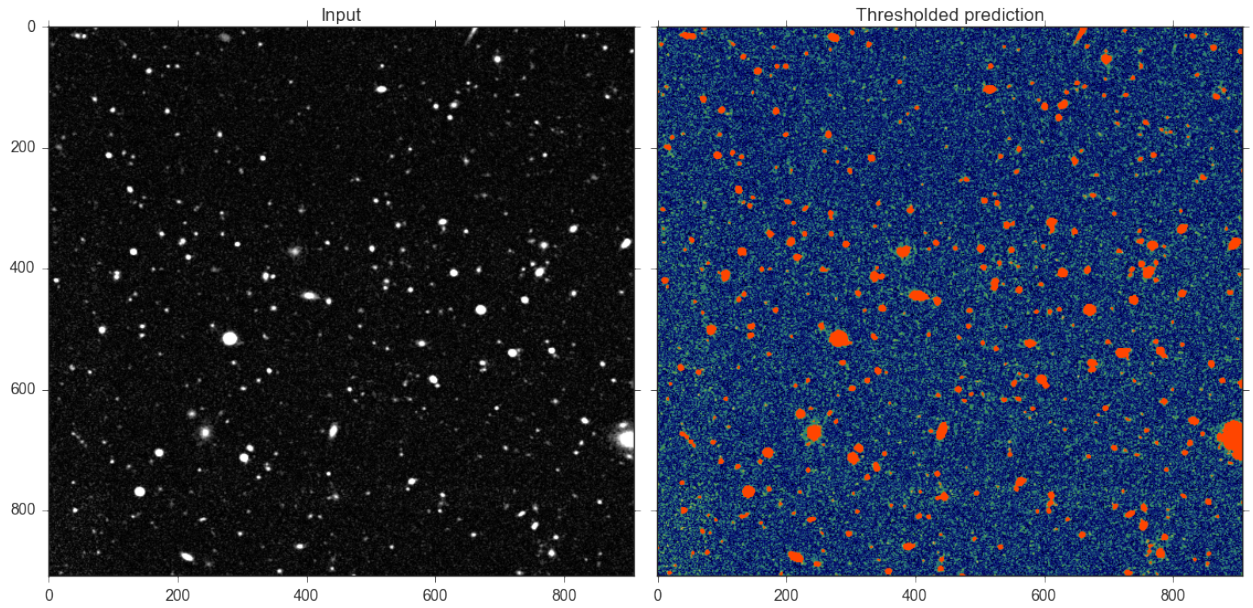
The code is not tied to a specific segmentation such that it can be used in a toy problem to detect circles in a noisy image.



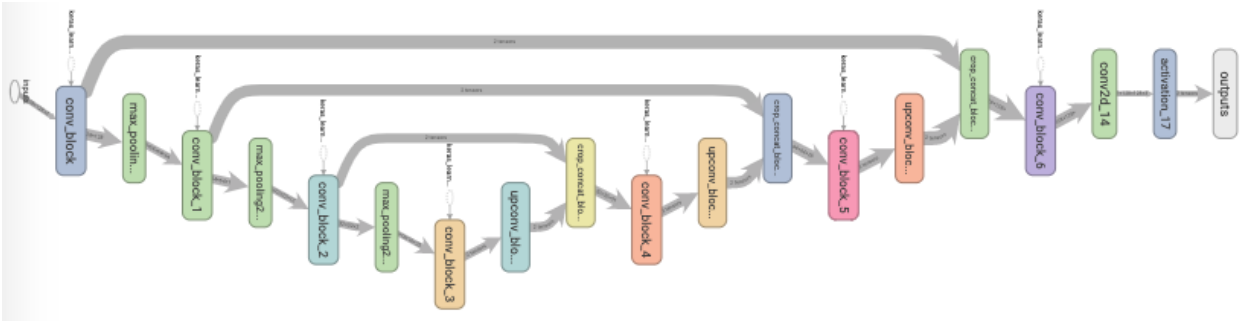
To more complex application such as the detection of radio frequency interference (RFI) in radio astronomy.



Or to detect galaxies and star in wide field imaging data.



The architectural elements of a U-Net consist of a contracting and expanding path:



As you use **unet** for your exciting discoveries, please cite the paper that describes the package:

```
@article{akeret2017radio,
  title={Radio frequency interference mitigation using deep convolutional neural networks},
  author={Akeret, Joel and Chang, Chihway and Lucchi, Aurelien and Refregier, Alexandre},
  journal={Astronomy and Computing},
  volume={18},
  pages={35--39},
  year={2017},
  publisher={Elsevier}
}
```

CHAPTER 1

Contents

1.1 Installation

The project is hosted on GitHub. Get a copy by running:

```
$ git clone https://github.com/jakeret/unet.git
```

Install the package like this:

```
$ cd unet
$ pipenv install --dev
```

1.2 Usage

To use Tensorflow Unet in a project:

```
import unet
from unet.datasets import circles

#loading the datasets
train_dataset, validation_dataset = circles.load_data(100, nx=200, ny=200,
                                                      splits=(0.8, 0.2))

#building the model
unet_model = unet.build_model(channels=circles.channels,
                              num_classes=circles.classes,
                              layer_depth=3,
                              filters_root=16)

unet.finalize_model(unet_model)
```

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```
#training and validating the model
trainer = unet.Trainer(checkpoint_callback=False)
trainer.fit(unet_model,
            train_dataset,
            validation_dataset,
            epochs=5,
            batch_size=1)
```

Once the model is trained it can be saved using Tensorflow's save format:

```
from unet import custom_objects
unet_model.save(<save_path>)
```

and loaded by using:

```
from unet import custom_objects
reconstructed_model = tf.keras.models.load_model(<save_path>, custom_objects=custom_
↪objects)
```

Keep track of the learning progress using *Tensorboard*. **unet** automatically outputs relevant summaries.

1.3 unet package

1.3.1 unet.unet module

class unet.unet.**ConvBlock**(*layer_idx*, *filters_root*, *kernel_size*, *dropout_rate*, *padding*, *activation*, ***kwargs*)

Bases: tensorflow.python.keras.engine.base_layer.Layer

call(*inputs*, *training=None*, ***kwargs*)

This is where the layer's logic lives.

Note here that *call()* method in *tf.keras* is little bit different from *keras* API. In *keras* API, you can pass support masking for layers as additional arguments. Whereas *tf.keras* has *compute_mask()* method to support masking.

Parameters

- **inputs** – Input tensor, or list/tuple of input tensors.
- ****kwargs** – Additional keyword arguments. Currently unused.

Returns A tensor or list/tuple of tensors.

get_config()

Returns the config of the layer.

A layer config is a Python dictionary (serializable) containing the configuration of a layer. The same layer can be reinstantiated later (without its trained weights) from this configuration.

The config of a layer does not include connectivity information, nor the layer class name. These are handled by *Network* (one layer of abstraction above).

Returns Python dictionary.

class unet.unet.**CropConcatBlock**(*trainable=True*, *name=None*, *dtype=None*, *dynamic=False*, ***kwargs*)

Bases: tensorflow.python.keras.engine.base_layer.Layer

call(*x*, *down_layer*, ***kwargs*)
This is where the layer's logic lives.

Note here that *call()* method in *tf.keras* is little bit different from *keras* API. In *keras* API, you can pass support masking for layers as additional arguments. Whereas *tf.keras* has *compute_mask()* method to support masking.

Parameters

- **inputs** – Input tensor, or list/tuple of input tensors.
- ****kwargs** – Additional keyword arguments. Currently unused.

Returns A tensor or list/tuple of tensors.

class unet.unet.**UpconvBlock**(*layer_idx*, *filters_root*, *kernel_size*, *pool_size*, *padding*, *activation*, ***kwargs*)
Bases: tensorflow.python.keras.engine.base_layer.Layer

call(*inputs*, ***kwargs*)
This is where the layer's logic lives.

Note here that *call()* method in *tf.keras* is little bit different from *keras* API. In *keras* API, you can pass support masking for layers as additional arguments. Whereas *tf.keras* has *compute_mask()* method to support masking.

Parameters

- **inputs** – Input tensor, or list/tuple of input tensors.
- ****kwargs** – Additional keyword arguments. Currently unused.

Returns A tensor or list/tuple of tensors.

get_config()
Returns the config of the layer.

A layer config is a Python dictionary (serializable) containing the configuration of a layer. The same layer can be reinstantiated later (without its trained weights) from this configuration.

The config of a layer does not include connectivity information, nor the layer class name. These are handled by *Network* (one layer of abstraction above).

Returns Python dictionary.

unet.unet.**build_model**(*nx: Optional[int] = None*, *ny: Optional[int] = None*, *channels: int = 1*, *num_classes: int = 2*, *layer_depth: int = 5*, *filters_root: int = 64*, *kernel_size: int = 3*, *pool_size: int = 2*, *dropout_rate: int = 0.5*, *padding: str = 'valid'*, *activation: Union[str, Callable] = 'relu'*) → tensorflow.python.keras.engine.training.Model
Constructs a U-Net model

Parameters

- **nx** – (Optional) image size on x-axis
- **ny** – (Optional) image size on y-axis
- **channels** – number of channels of the input tensors
- **num_classes** – number of classes
- **layer_depth** – total depth of unet
- **filters_root** – number of filters in top unet layer
- **kernel_size** – size of convolutional layers

- **pool_size** – size of maxplool layers
- **dropout_rate** – rate of dropout
- **padding** – padding to be used in convolutions
- **activation** – activation to be used

Returns A TF Keras model

unet.unet.**finalize_model**(*model: tensorflow.python.keras.engine.training.Model*, *loss: Union[Callable, str, None] = <function categorical_crossentropy>*, *optimizer: Optional = None*, *metrics: Optional[List[Union[Callable, str]]] = None*, *dice_coefficient: bool = True*, *auc: bool = True*, *mean_iou: bool = True*, ***opt_kwargs*)

Configures the model for training by setting, loss, optimzer, and tracked metrics

Parameters

- **model** – the model to compile
- **loss** – the loss to be optimized. Defaults to *categorical_crossentropy*
- **optimizer** – the optimizer to use. Defaults to *Adam*
- **metrics** – List of metrics to track. Is extended by *crossentropy* and *accuracy*
- **dice_coefficient** – Flag if the dice coefficient metric should be tracked
- **auc** – Flag if the area under the curve metric should be tracked
- **mean_iou** – Flag if the mean over intersection over union metric should be tracked
- **opt_kwargs** – key word arguments passed to default optimizer (Adam), e.g. learning rate

1.3.2 unet.trainer module

class unet.trainer.**Trainer**(*name: Optional[str] = 'unet'*, *log_dir_path: Union[pathlib.Path, str, None] = None*, *checkpoint_callback: Union[tensorflow.python.keras.callbacks.TensorBoard, bool, None] = True*, *tensorboard_callback: Union[tensorflow.python.keras.callbacks.TensorBoard, bool, None] = True*, *tensorboard_images_callback: Union[unet.callbacks.TensorBoardImageSummary, bool, None] = True*, *callbacks: Optional[List[tensorflow.python.keras.callbacks.Callback]] = None*, *learning_rate_scheduler: Union[unet.schedulers.SchedulerType, tensorflow.python.keras.callbacks.Callback, None] = None*, ***scheduler_opts*)

Bases: object

Fits a given model to a datasets and configres learning rate schedulers and various callbacks

Parameters

- **name** – Name of the model, used to build the target log directory if no explicit path is given
- **log_dir_path** – Path to the directory where the model and tensorboard summaries should be stored
- **checkpoint_callback** – Flag if checkpointing should be enabled. Alternatively a callback instance can be passed

- **tensorboard_callback** – Flag if information should be stored for tensorboard. Alternatively a callback instance can be passed
- **tensorboard_images_callback** – Flag if intermediate predictions should be stored in Tensorboard. Alternatively a callback instance can be passed
- **callbacks** – List of additional callbacks
- **learning_rate_scheduler** – The learning rate to be used. Either None for a constant learning rate, a *Callback* or a *SchedulerType*
- **scheduler_opts** – Further kwargs passed to the learning rate scheduler

evaluate(*model: tensorflow.python.keras.engine.training.Model*, *test_dataset: Optional[tensorflow.python.data.ops.dataset_ops.DatasetV2] = None*, *shape: Tuple[int, int, int] = None*)

fit(*model: tensorflow.python.keras.engine.training.Model*, *train_dataset: tensorflow.python.data.ops.dataset_ops.DatasetV2*, *validation_dataset: Optional[tensorflow.python.data.ops.dataset_ops.DatasetV2] = None*, *test_dataset: Optional[tensorflow.python.data.ops.dataset_ops.DatasetV2] = None*, *epochs=10*, *batch_size=1*, ***fit_kwargs*)

Fits the model to the given data

Parameters

- **model** – The model to be fit
- **train_dataset** – The dataset used for training
- **validation_dataset** – (Optional) The dataset used for validation
- **test_dataset** – (Optional) The dataset used for test
- **epochs** – Number of epochs
- **batch_size** – Size of minibatches
- **fit_kwargs** – Further kwargs passd to *model.fit*

unet.trainer.**build_log_dir_path**(*root: Optional[str] = 'unet'*) → str

1.3.3 unet.utils module

unet.utils.**crop_image_and_label_to_shape**(*shape: Tuple[int, int, int]*)

unet.utils.**crop_labels_to_shape**(*shape: Tuple[int, int, int]*)

unet.utils.**crop_to_shape**(*data, shape: Tuple[int, int, int]*)

Crops the array to the given image shape by removing the border

Parameters

- **data** – the array to crop, expects a tensor of shape [batches, nx, ny, channels]
- **shape** – the target shape [batches, nx, ny, channels]

unet.utils.**to_rgb**(*img: numpy.array*)

Converts the given array into a RGB image and normalizes the values to [0, 1). If the number of channels is less than 3, the array is tiled such that it has 3 channels. If the number of channels is greater than 3, only the first 3 channels are used

Parameters **img** – the array to convert [bs, nx, ny, channels]

Returns **img** the rgb image [bs, nx, ny, 3]

1.3.4 Subpackages

unet.datasets package

Submodules

unet.datasets.circles module

unet.datasets.circles.**load_data**(*count: int*, *splits: Tuple[float] = (0.7*, *0.2*, *0.1)*, ***kwargs*) → List[tensorflow.python.data.ops.dataset_ops.DatasetV2]

unet.datasets.oxford_iiit_pet module

Module contents

1.3.5 Submodules

1.3.6 unet.callbacks module

class unet.callbacks.**TensorBoardImageSummary**(*name*, *logdir: str*, *dataset: tensorflow.python.data.ops.dataset_ops.DatasetV2*, *max_outputs: int = None*)

Bases: tensorflow.python.keras.callbacks.Callback

combine_to_image(*images: numpy.array*, *labels: numpy.array*, *predictions: numpy.array*) → numpy.array

Concatenates the three tensors to one RGB image

Parameters

- **images** – images tensor, shape [None, nx, ny, channels]
- **labels** – labels tensor, shape [None, nx, ny, 1] for sparse or [None, nx, ny, classes] for one-hot
- **predictions** – labels tensor, shape [None, nx, ny, classes]

Returns image tensor, shape [None, nx, 3 x ny, 3]

on_epoch_end(*epoch*, *logs=None*)

Called at the end of an epoch.

Subclasses should override for any actions to run. This function should only be called during TRAIN mode.

Parameters

- **epoch** – Integer, index of epoch.
- **logs** –

  Dict, metric results for this training epoch, and for the validation epoch if validation is performed. Validation result keys are prefixed with *val_*. For training epoch, the values of the

  Model's metrics are returned. Example : *{'loss': 0.2, 'acc': 0.7}*.

class unet.callbacks.**TensorBoardWithLearningRate**(*log_dir='logs'*, *histogram_freq=0*, *write_graph=True*, *write_images=False*, *update_freq='epoch'*, *profile_batch=2*, *embeddings_freq=0*, *embeddings_metadata=None*, ***kwargs*)

Bases: tensorflow.python.keras.callbacks.TensorBoard

on_epoch_end(*batch*, *logs=None*)

Runs metrics and histogram summaries at epoch end.

1.3.7 unet.metrics module

unet.metrics.**dice_coefficient**(*y_true*, *y_pred*, *smooth=1*)

unet.metrics.**mean_iou**(*y_true*, *y_pred*)

1.3.8 unet.schedulers module

class unet.schedulers.**LearningRateScheduler**(*schedule: Callable[[int], float]*, *steps_per_epoch: int*, *verbose=0*)

Bases: tensorflow.python.keras.callbacks.Callback

Learning rate scheduler. :param schedule: a function that takes an step index as input

(integer, indexed from 0) and returns a new learning rate as output (float).

Parameters **verbose** – int. 0: quiet, 1: update messages.

on_epoch_end(*epoch*, *logs=None*)

Called at the end of an epoch.

Subclasses should override for any actions to run. This function should only be called during TRAIN mode.

Parameters

- **epoch** – Integer, index of epoch.
- **logs** –

  Dict, metric results for this training epoch, and for the validation epoch if validation is performed. Validation result keys are prefixed with *val_*. For training epoch, the values of the

  Model's metrics are returned. Example : *{'loss': 0.2, 'acc': 0.7}*.

on_train_batch_begin(*batch*, *logs=None*)

Called at the beginning of a training batch in *fit* methods.

Subclasses should override for any actions to run.

Note that if the *steps_per_execution* argument to *compile* in *tf.keras.Model* is set to *N*, this method will only be called every *N* batches.

Parameters

- **batch** – Integer, index of batch within the current epoch.
- **logs** – Dict, contains the return value of *model.train_step*. Typically, the values of the *Model*'s metrics are returned. Example: *{'loss': 0.2, 'accuracy': 0.7}*.

on_train_batch_end(*batch*, *logs=None*)
Called at the end of a training batch in *fit* methods.

Subclasses should override for any actions to run.

Note that if the *steps_per_execution* argument to *compile* in *tf.keras.Model* is set to *N*, this method will only be called every *N* batches.

Parameters

- **batch** – Integer, index of batch within the current epoch.
- **logs** – Dict. Aggregated metric results up until this batch.

class unet.schedulers.**SchedulerType**
Bases: enum.Enum

An enumeration.

WARMUP_LINEAR_DECAY = 'warmup-linear-decay'

class unet.schedulers.**WarmupLinearDecaySchedule**(*warmup_steps*, *total_steps*, *learning_rate*, *min_lr=0.0*)
Bases: object

Linear warmup and then linear decay. Linearly increases learning rate from 0 to 1 over *warmup_steps* training steps. Linearly decreases learning rate from 1. to 0. over remaining *t_total - warmup_steps* steps.

unet.schedulers.**get**(*scheduler: unet.schedulers.SchedulerType*, *train_dataset_size: int*, *learning_rate: float*, ***hyperparams*)

1.3.9 Module contents

1.4 Contributing

Contributions are welcome, and they are greatly appreciated! Every little bit helps, and credit will always be given.

You can contribute in many ways:

1.4.1 Types of Contributions

Report Bugs

If you are reporting a bug, please include:

- Your operating system name and version.
- Any details about your local setup that might be helpful in troubleshooting.
- Detailed steps to reproduce the bug.

Fix Bugs

Implement Features

Write Documentation

Tensorflow Unet could always use more documentation, whether as part of the official Tensorflow Unet docs, in docstrings, or even on the web in blog posts, articles, and such.

Submit Feedback

If you are proposing a feature:

- Explain in detail how it would work.
- Keep the scope as narrow as possible, to make it easier to implement.
- Remember that this is a volunteer-driven project, and that contributions are welcome :)

1.4.2 Pull Request Guidelines

Before you submit a pull request, check that it meets these guidelines:

1. The pull request should include tests.
2. If the pull request adds functionality, the docs should be updated. Put your new functionality into a function with a docstring, and add the feature to the list in README.rst.
3. The pull request should work for Python 2.6, 2.7, and 3.3, and for PyPy. make sure that the tests pass for all supported Python versions.

1.5 Credits

1.5.1 Development Lead

- @jakeret

1.5.2 Contributors

- @tdrobbins
- @ck090
- gokarslan

1.5.3 Citations

As you use **unet** for your exciting discoveries, please cite the paper that describes the package:

J. Akeret, C. Chang, A. Lucchi, A. Refregier, Published in Astronomy and Computing (2017)

1.6 Changelog

1.6.1 Version 0.1

- Feature A added
- FIX: nasty bug #1729 fixed
- add your changes here!

1.7 License

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