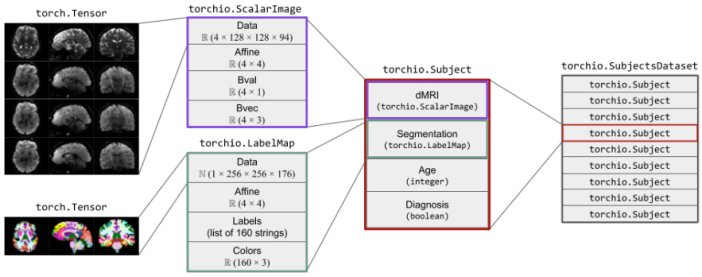
Image

The `Image` class, representing one medical image, stores a 4D tensor, whose voxels encode, e.g., signal intensity or segmentation labels, and the corresponding affine transform, typically a rigid (Euclidean) transform, to convert voxel indices to world coordinates in mm. Arbitrary fields such as acquisition parameters may also be stored.

Subclasses are used to indicate specific types of images, such as `ScalarImage` and `LabelMap`, which are used to store, e.g., CT scans and segmentations, respectively.

An instance of `Image` can be created using a filepath, a PyTorch tensor, or a NumPy array. This class uses lazy loading, i.e., the data is not loaded from disk at instantiation time. Instead, the data is only loaded when needed for an operation (e.g., if a transform is applied to the image).

The figure below shows two instances of `Image`. The instance of `ScalarImage` contains a 4D tensor representing a diffusion MRI, which contains four 3D volumes (one per gradient direction), and the associated affine matrix. Additionally, it stores the strength and direction for each of the four gradients. The instance of `LabelMap` contains a brain parcellation of the same subject, the associated affine matrix, and the name and color of each brain structure.



class torchio.**ScalarImage**(*args, **kwargs) [source]

Bases: `torchio.data.image.Image`

Image whose pixel values represent scalars.

EXAMPLE

```
>>> import torch
>>> import torchio as tio
>>> # Loading from a file
>>> t1_image = tio.ScalarImage('t1.nii.gz')
>>> dmri = tio.ScalarImage(tensor=torch.rand(32, 128, 128, 88))
>>> image = tio.ScalarImage('safe_image.nrrd', check_nans=False)
>>> data, affine = image.data, image.affine
>>> affine.shape
(4, 4)
>>> image.data is image[tio.DATA]
True
>>> image.data is image.tensor
True
>>> type(image.data)
torch.Tensor
```

See `Image` for more information.

class torchio.**LabelMap**(*args, **kwargs) [source]

Bases: `torchio.data.image.Image`

Image whose pixel values represent categorical labels.

EXAMPLE

```
>>> import torch
>>> import torchio as tio
>>> labels = tio.LabelMap(tensor=torch.rand(1, 128, 128, 68) > 0.5)
>>> labels = tio.LabelMap('t1_seg.nii.gz')  # loading from a file
>>> tpm = tio.LabelMap(                     # loading from files
...     'gray_matter.nii.gz',
...     'white_matter.nii.gz',
...     'csf.nii.gz',
... )
```

Intensity transforms are not applied to these images.

Nearest neighbor interpolation is always used to resample label maps, independently of the specified interpolation type in the transform instantiation.

See `Image` for more information.

class torchio.**Image**(path: typing.Optional[typing.Union[str, os.PathLike, typing.Sequence[typing.Union[str, os.PathLike]]]] = None, type: typing.Optional[str] = None, tensor: typing.Optional[typing.Union[torch.Tensor, numpy.ndarray]] = None, affine: typing.Optional[typing.Union[torch.Tensor, numpy.ndarray]] = None, check_nans: bool = False, reader: typing.Callable = <function read_image>, **kwargs: typing.Dict[str, typing.Any]) [source]

Bases: `dict`

TorchIO image.

For information about medical image orientation, check out NiBabel docs, the 3D Slicer wiki, Graham Wideman's website, FSL docs or SimpleITK docs.

PARAMETERS

- **path** – Path to a file or sequence of paths to files that can be read by `SimpleITK` or `nibabel`, or to a directory containing DICOM files. If `tensor` is given, the data in `path` will not be read. If a sequence of paths is given, data will be concatenated on the channel dimension so spatial dimensions must match.
- **type** – Type of image, such as `torchio.INTENSITY` or `torchio.LABEL`. This will be used by the transforms to decide whether to apply an operation, or which interpolation to use when resampling. For example, preprocessing and augmentation intensity transforms will only be applied to images with type `torchio.INTENSITY`. Spatial transforms will be applied to all types, and nearest neighbor interpolation is always used to resample images with type `torchio.LABEL`. The type `torchio.SAMPLING_MAP` may be used with instances of `WeightedSampler`.
- **tensor** – If `path` is not given, `tensor` must be a 4D `torch.Tensor` or NumPy array with dimensions (C, W, H, D).
- **affine** – 4×4 matrix to convert voxel coordinates to world coordinates. If `None`, an identity matrix will be used. See the NiBabel docs on coordinates for more information.
- **check_nans** – If `True`, issues a warning if NaNs are found in the image. If `False`, images will not be checked for the presence of NaNs.
- **reader** – Callable object that takes a path and returns a 4D tensor and a 2D, 4×4 affine matrix. This can be used if your data is saved in a custom format, such as `.npy` (see example below). If the affine matrix is `None`, an identity matrix will be used.
- ****kwargs** – Items that will be added to the image dictionary, e.g. acquisition parameters.

TorchIO images are lazy loaders, i.e. the data is only loaded from disk when needed.

EXAMPLE

```
>>> import torchio as tio
>>> import numpy as np
>>> image = tio.ScalarImage('t1.nii.gz')  # subclass of Image
>>> image  # not loaded yet
ScalarImage(path: t1.nii.gz; type: intensity)
>>> times_two = 2 * image.data  # data is loaded and cached here
>>> image
ScalarImage(shape: (1, 256, 256, 176); spacing: (1.00, 1.00, 1.00); orientation: PIR+; me
>>> image.save('doubled_image.nii.gz')
>>> def numpy_reader(path):
...     data = np.load(path).as_type(np.float32)
...     affine = np.eye(4)
...     return data, affine
>>> image = tio.ScalarImage('t1.npy', reader=numpy_reader)
```

property affine: numpy.ndarray

Affine matrix to transform voxel indices into world coordinates.

as_pil(transpose=True) [source]

Get the image as an instance of `PIL.Image`.

> Note
>
> Values will be clamped to 0-255 and cast to uint8.

> Note
>
> To use this method, *Pillow* needs to be installed: *pip install Pillow*.

as_sitk(kwargs) → SimpleITK.SimpleITK.Image** [source]

Get the image as an instance of `sitk.Image`.

axis_name_to_index(axis: str) → int [source]

Convert an axis name to an axis index.

PARAMETERS

axis – Possible inputs are `'Left'`, `'Right'`, `'Anterior'`, `'Posterior'`, `'Inferior'`, `'Superior'`. Lower-case versions and first letters are also valid, as only the first letter will be used.

> Note
>
> If you are working with animals, you should probably use `'Superior'`, `'Inferior'`, `'Anterior'` and `'Posterior'` for `'Dorsal'`, `'Ventral'`, `'Rostral'` and `'Caudal'`, respectively.

> Note
>
> If your images are 2D, you can use `'Top'`, `'Bottom'`, `'Left'` and `'Right'`.

property bounds: numpy.ndarray

Position of centers of voxels in smallest and largest indices.

property data: torch.Tensor

Tensor data. Same as `Image.tensor`.

static flip_axis(axis: str) → str [source]

Return the opposite axis label. For example, `'L'` -> `'R'`.

PARAMETERS

axis – Axis label, such as `'L'` or `'left'`.

classmethod from_sitk(sitk_image) [source]

Instantiate a new TorchIO image from a `sitk.Image`.

EXAMPLE

EXAMPLE

```
>>> import torchio as tio
>>> import SimpleITK as sitk
>>> sitk_image = sitk.Image(20, 30, 40, sitk.sitkUInt16)
>>> tio.LabelMap.from_sitk(sitk_image)
LabelMap(shape: (1, 20, 30, 40); spacing: (1.00, 1.00, 1.00); orientation: LPS+; mem
>>> sitk_image = sitk.Image((224, 224), sitk.sitkVectorFloat32, 3)
>>> tio.ScalarImage.from_sitk(sitk_image)
ScalarImage(shape: (3, 224, 224, 1); spacing: (1.00, 1.00, 1.00); orientation: LPS+;
```

`get_bounds() → Tuple[Tuple[float, float], Tuple[float, float], Tuple[float, float]]` [source]

Get minimum and maximum world coordinates occupied by the image.

`get_center(lps: bool = False) → Tuple[float, float, float]` [source]

Get image center in RAS+ or LPS+ coordinates.

PARAMETERS

lps – If `True`, the coordinates will be in LPS+ orientation, i.e. the first dimension grows towards the left, etc. Otherwise, the coordinates will be in RAS+ orientation.

`property height: int`

Image height, if 2D.

`property itemsize`

Element size of the data type.

`load() → None` [source]

Load the image from disk.

RETURNS

Tuple containing a 4D tensor of size (C, W, H, D) and a 2D 4×4 affine matrix to convert voxel indices to world coordinates.

`property memory: float`

Number of Bytes that the tensor takes in the RAM.

`property num_channels: int`

Get the number of channels in the associated 4D tensor.

`numpy() → numpy.ndarray` [source]

Get a NumPy array containing the image data.

`property orientation: Tuple[str, str, str]`

Orientation codes.

`property origin: Tuple[float, float, float]`

Center of first voxel in array, in mm.

`plot(**kwargs) → None` [source]

Plot image.

`save(path: Union[str, os.PathLike], squeeze: Optional[bool] = None) → None` [source]

Save image to disk.

PARAMETERS

- **path** – String or instance of `pathlib.Path`.
- **squeeze** – Whether to remove singleton dimensions before saving. If `None`, the array will be squeezed if the output format is JP(E)G, PNG, BMP or TIF(F).

`set_data(tensor: Union[torch.Tensor, numpy.ndarray])` [source]

Store a 4D tensor in the `data` key and attribute.

PARAMETERS

tensor – 4D tensor with dimensions (C, W, H, D).

`property shape: Tuple[int, int, int, int]`

Tensor shape as (C, W, H, D).

`show(viewer_path: Optional[Union[str, os.PathLike]] = None) → None` [source]

Open the image using external software.

PARAMETERS

viewer_path – Path to the application used to view the image. If `None`, the value of the environment variable `SITK_SHOW_COMMAND` will be used. If this variable is also not set, TorchIO will try to guess the location of ITK-SNAP and 3D Slicer.

RAISES

RuntimeError – If the viewer is not found.

`property spacing: Tuple[float, float, float]`

Voxel spacing in mm.

`property spatial_shape: Tuple[int, int, int]`

Tensor spatial shape as (W, H, D).

`property tensor: torch.Tensor`

Tensor data. Same as `Image.data`.

`to_gif(axis: int, duration: float, output_path: Union[str, os.PathLike], loop:`

```
    int = 0, rescale: bool = True, optimize: bool = True, reverse: bool = False)
    → None                                                                [source]
```

Save an animated GIF of the image.

PARAMETERS

- **axis** – Spatial axis (0, 1 or 2).
- **duration** – Duration of the full animation in seconds.
- **output_path** – Path to the output GIF file.
- **loop** – Number of times the GIF should loop. `0` means that it will loop forever.
- **rescale** – Use `RescaleIntensity` to rescale the intensity values to $[0, 255]$.
- **optimize** – If `True`, attempt to compress the palette by eliminating unused colors. This is only useful if the palette can be compressed to the next smaller power of 2 elements.
- **reverse** – Reverse the temporal order of frames.

```
property width: int
```

Image width, if 2D.

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