

Digital Images

Resolution

Resolution

DPI/PPI

FOV

Spatial Resolution

Anatomical Resolution

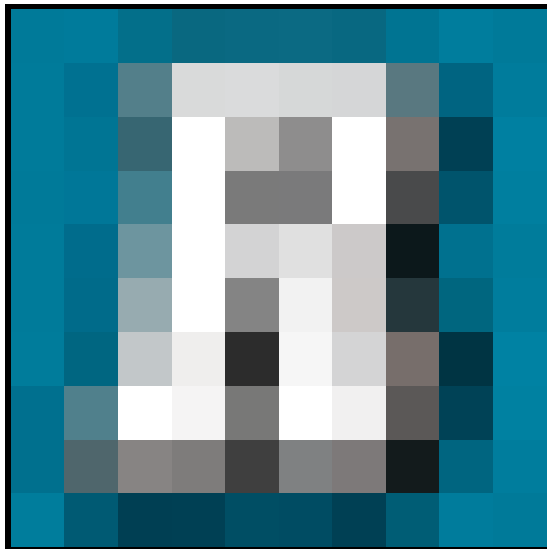
Temporal Resolution

Angular Resolution

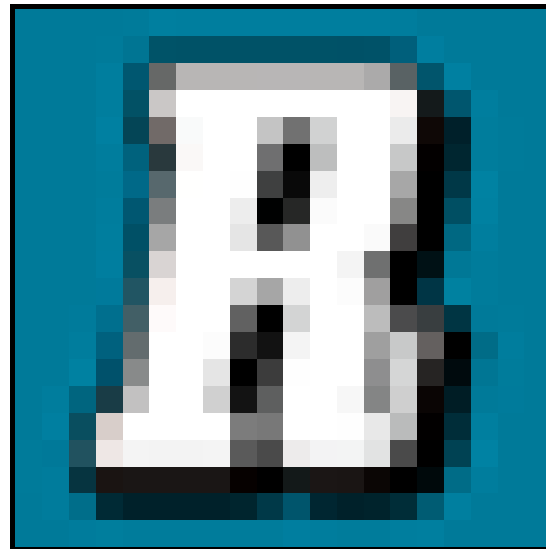
Resolution is the
detail of an image.

1) Resolution may refer to
the # of pixels in each
dimension.

10 x 10

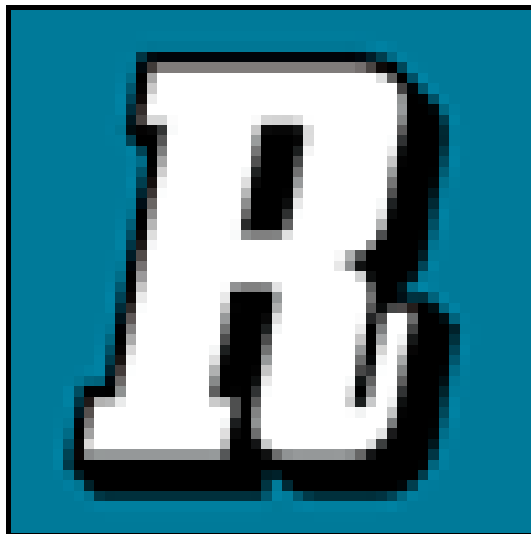


20 x 20



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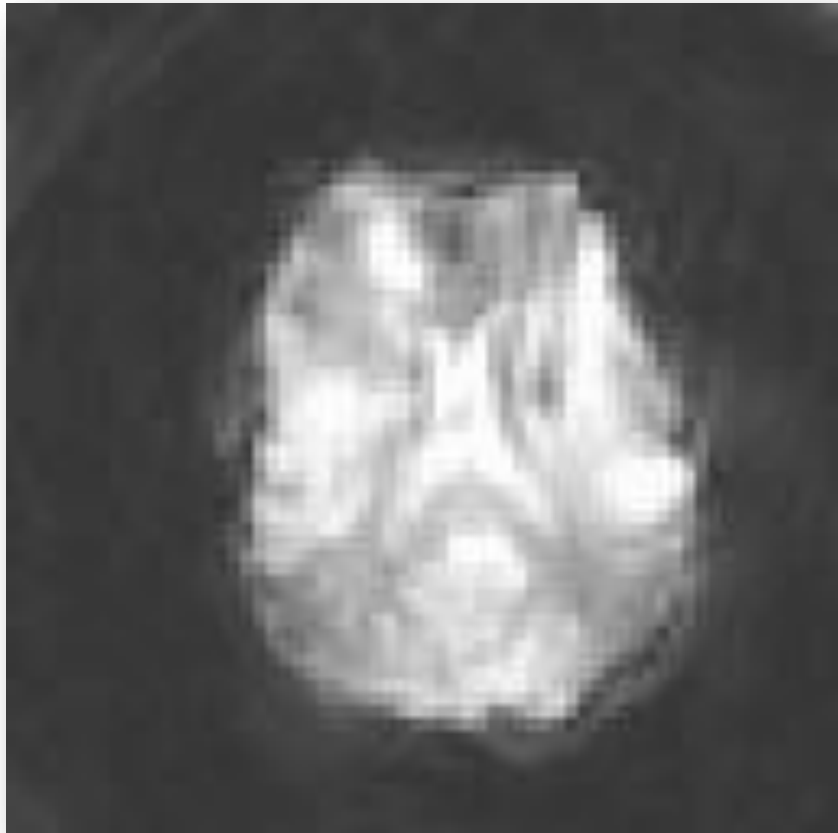
50 x 50



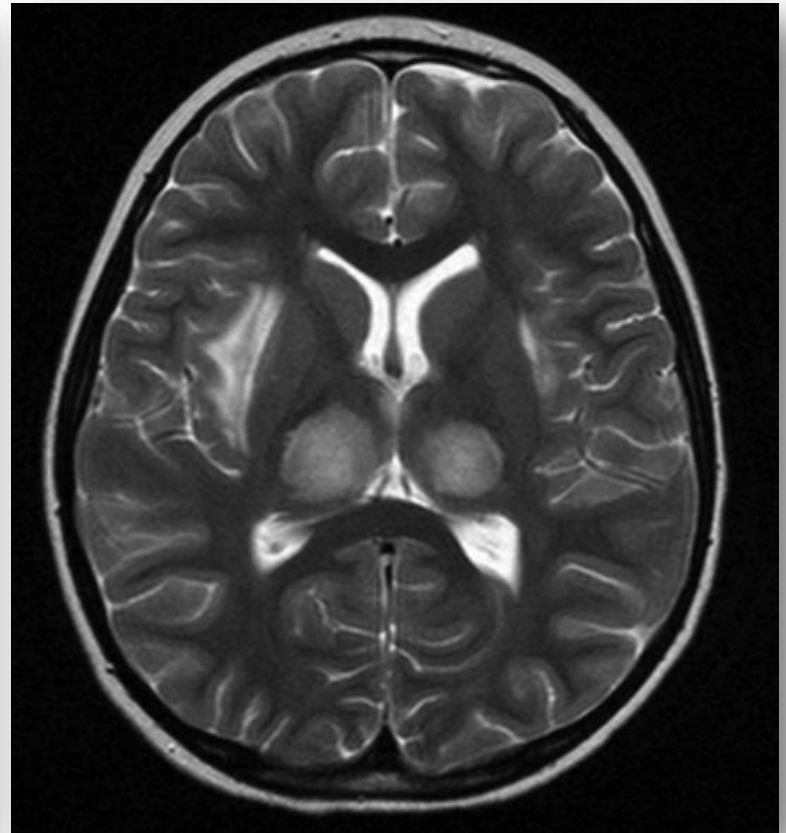
100 x 100



64x64



512x512

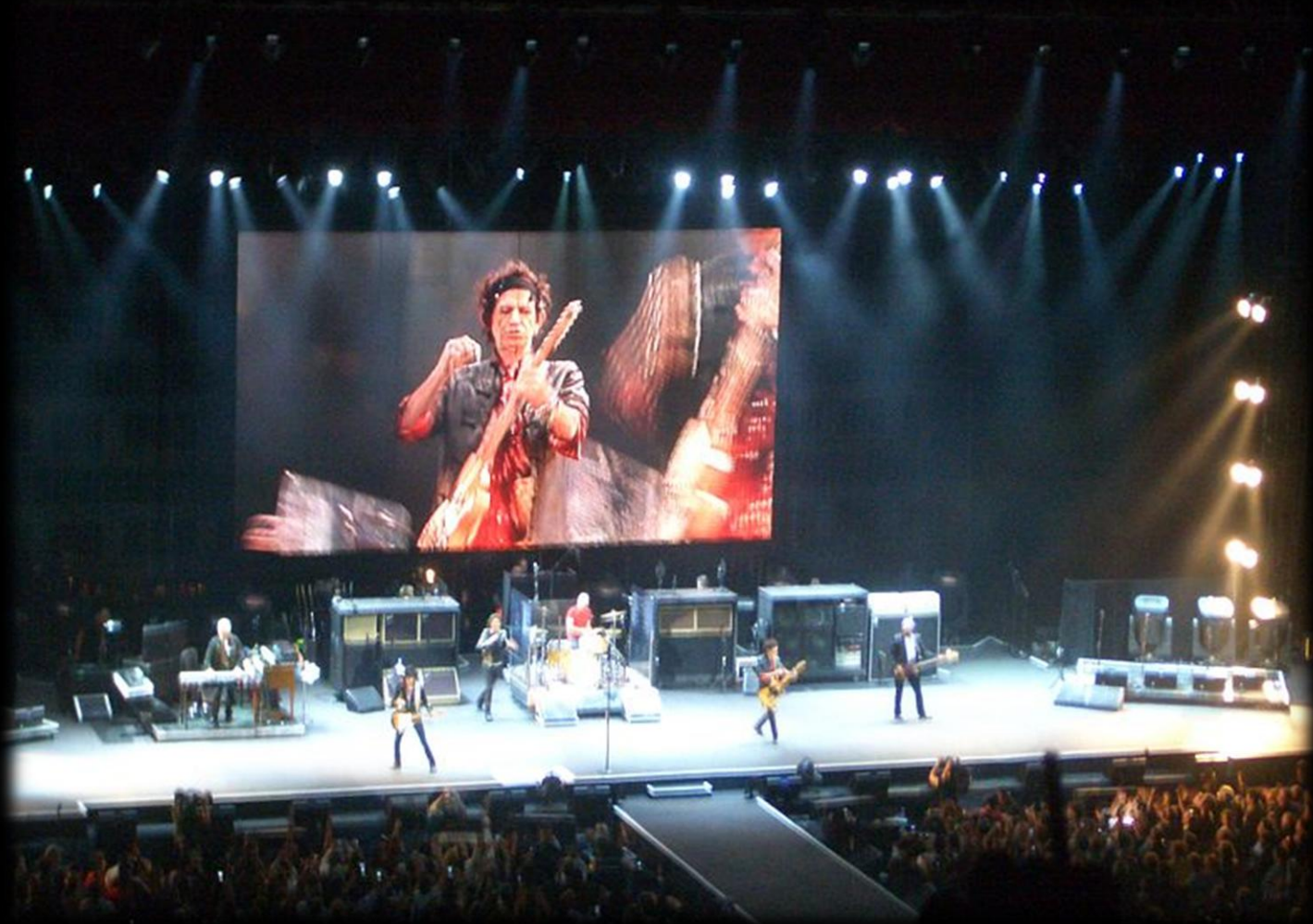


2) Resolution may refer to
Dots Per Inch.

"Dots Per
Inch" is
applied to
printed
documents,

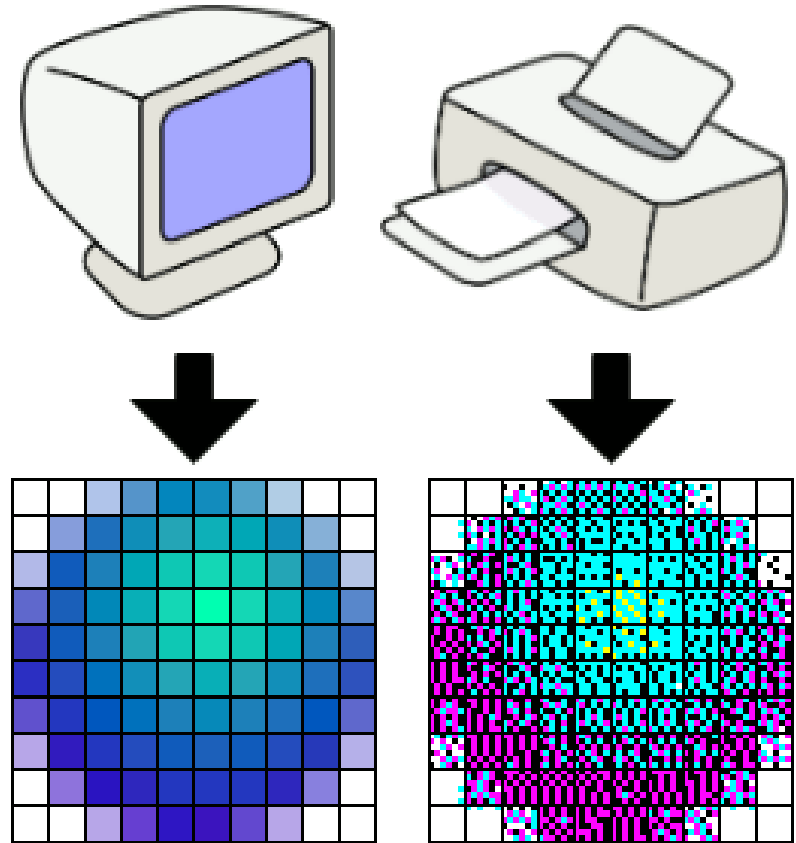


because a digital image has no
inherent physical size.



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However, A 10×10 pixel image requires more than 10×10 printer dots to accurately reproduce, -due to ink color limitations.



Pixels **P**er **I**nch (Pixel Density): a measure of the resolution of devices used to display digital images



204 ppi

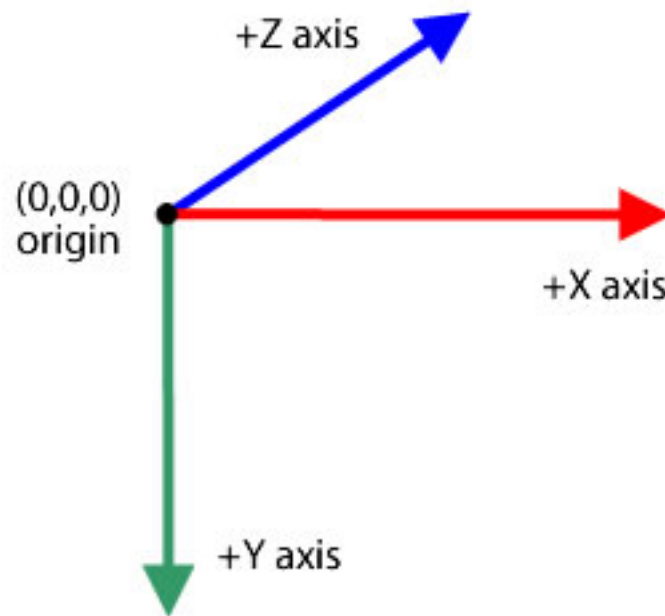


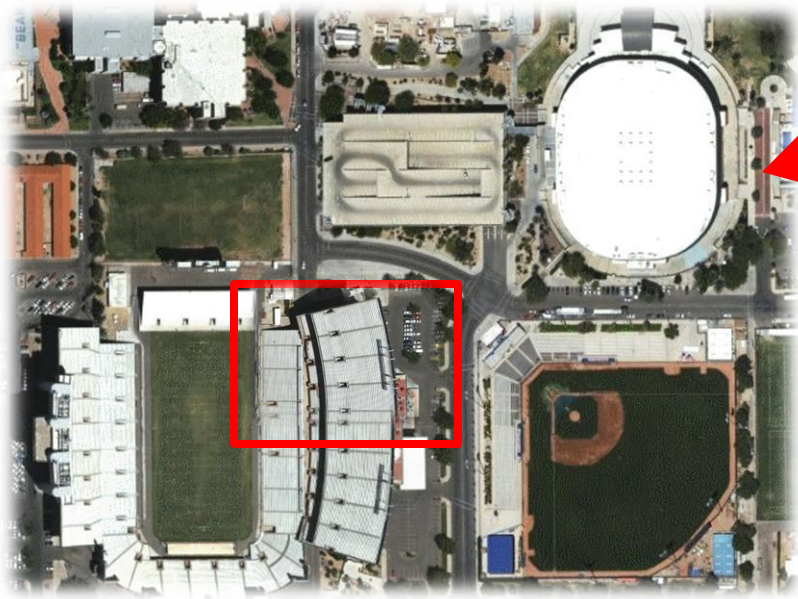
163 ppi

3) A third definition of
resolution
incorporates both number of
pixels and field of view.

FOV=The real world distance
represented by the picture.

FOV could be different in every direction (x,y or z).

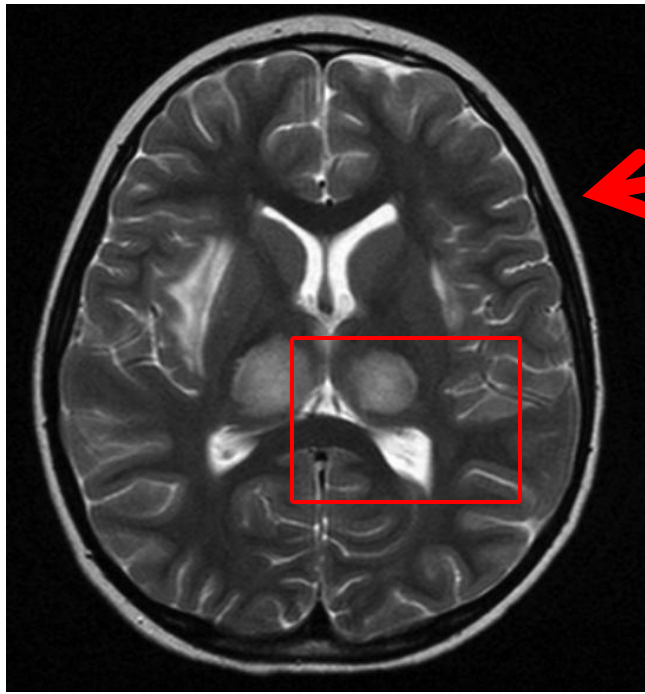




This picture has
a larger field of
view


This picture
has a
smaller field
of view





This picture has
a larger field of
view

This picture
has a
smaller field
of view

A red arrow pointing from the text 'This picture has a smaller field of view' towards the right side of the slide.

This more complex notion of resolution is sometimes called **spatial resolution**:

Spatial Resolution="the ability to distinguish between two separate but adjacent objects in the image".

Good spatial resolution allows you to distinguish objects that are closer together (e.g., 1 meter resolution is better than 6 meter resolution).



One Meter



Three Meter

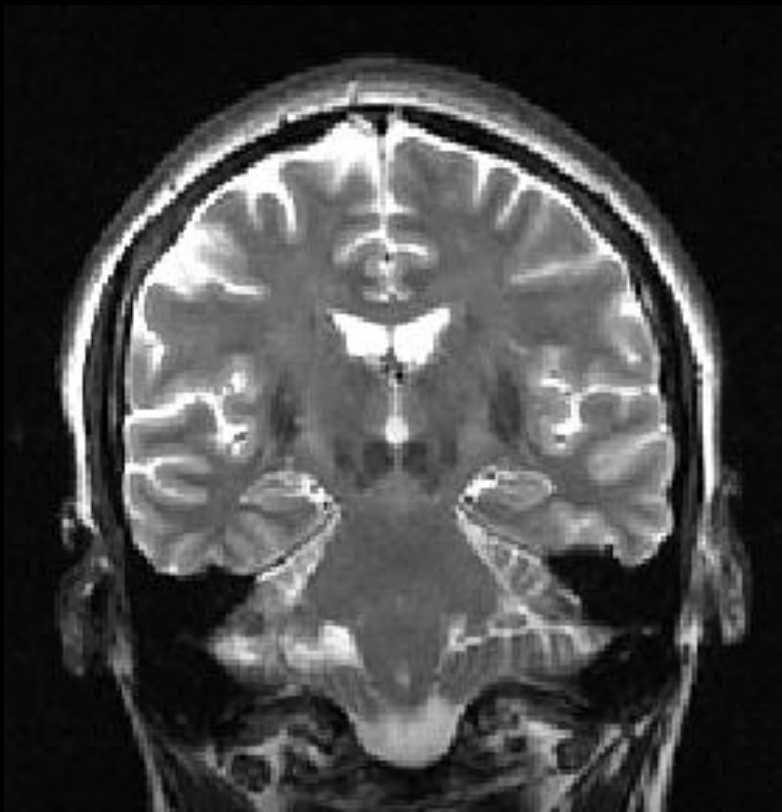


Six Meter

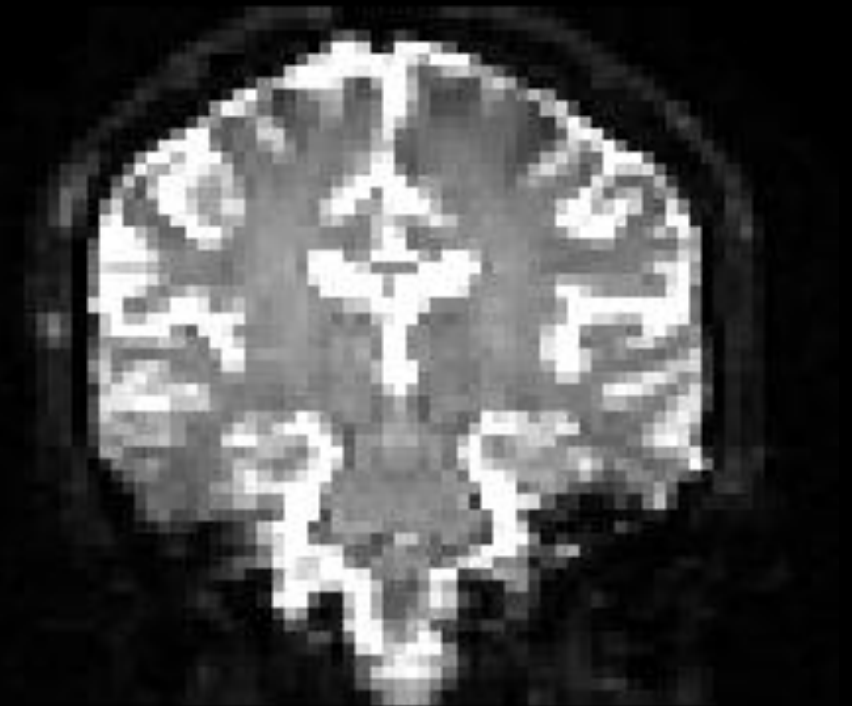


Ten Meter

Scale 1:24 000



1 mm



2.6 mm

If we know FOV and the # of pixels, we can calculate pixel size.

$$\text{FOV} / \# \text{pixels} = \text{pixel size}$$

High Resolution SPGR



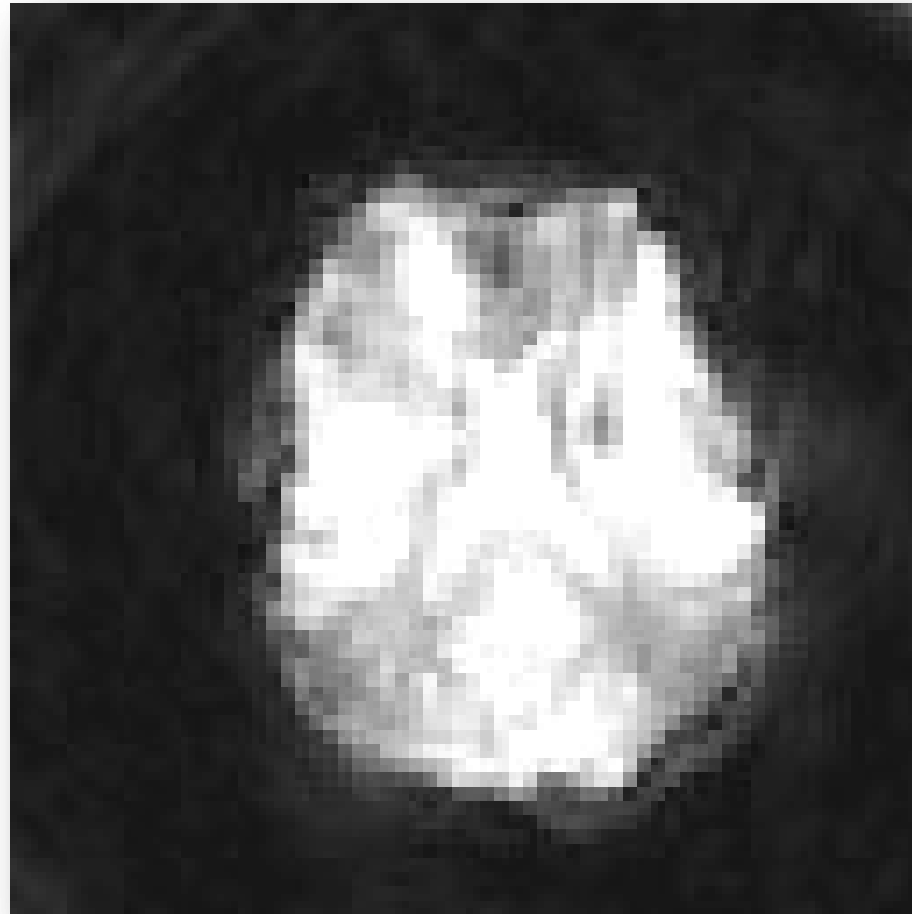
← 240 mm →

$240 \text{ mm} / 256 \text{ voxels} = 0.9375 \text{ mm voxel size}$

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fmri

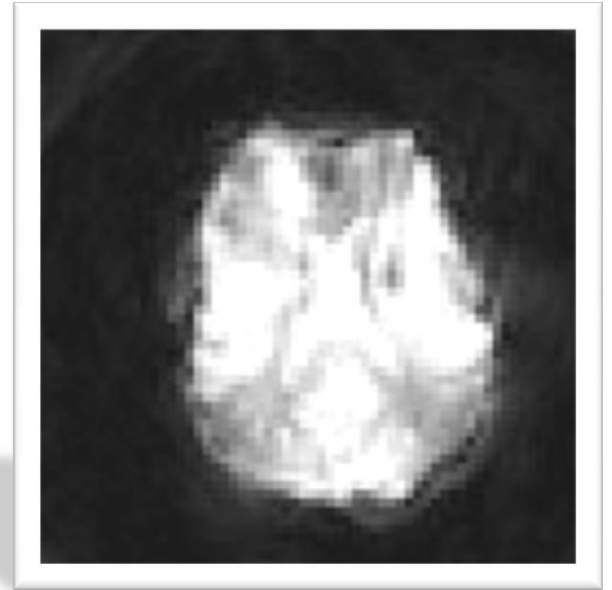
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← 220 mm →

$220 \text{ mm} / 64 \text{ voxels} = 3.4375 \text{ mm voxel size}$

The fmri image
(64x64) is lower
resolution



than the SPGR
(at 256x256).



All else being equal,

Big pixels → low res

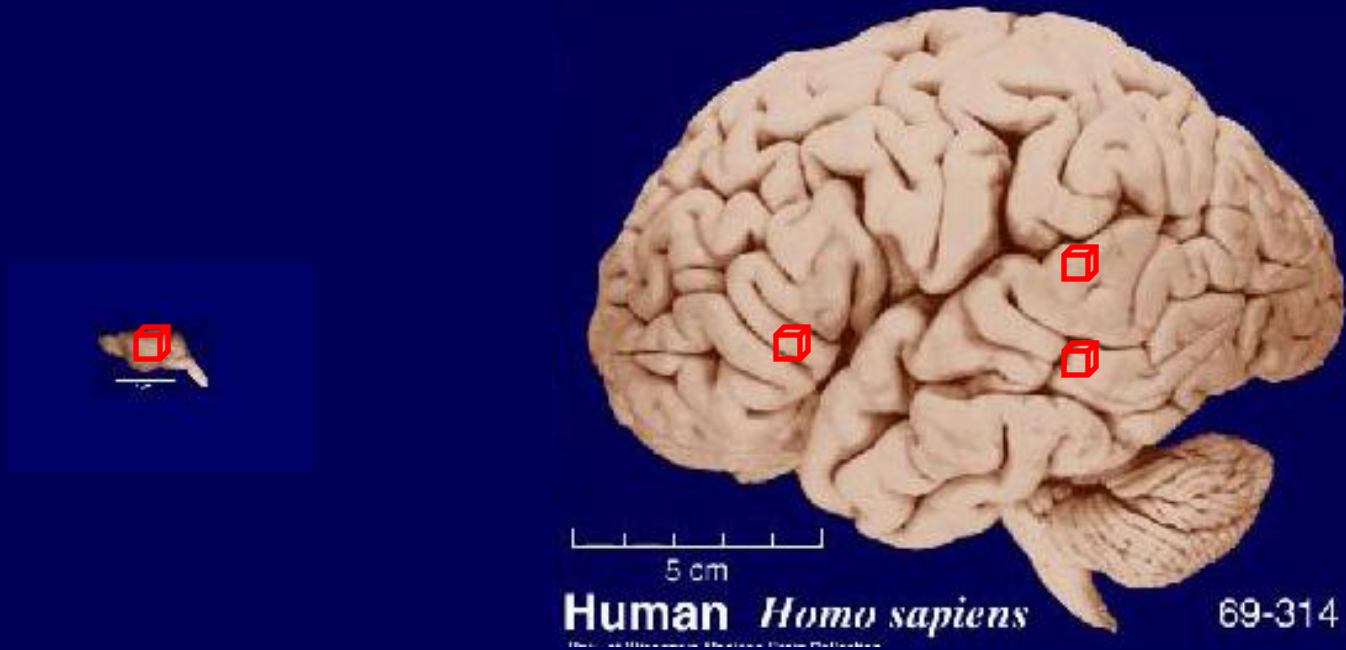
Small pixels → high res

Another closely related concept of resolution is

4) Anatomical Resolution

Anatomical resolution is the ability to resolve particular anatomical features.

a 5x5x5 mm voxel resolves fewer
features in a mouse brain
than in a human brain



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So the 5x5x5 mm voxel has less anatomical resolution in the mouse brain than in the adult human brain.

5) Temporal Resolution

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Temporal resolution refers to
the precision of a
measurement wrt time.

Movie cameras and
high-speed cameras can
resolve events with different
temporal resolutions.

The temporal resolution of
movies is usually
15 to 30
frames per second (fps),

while high-speed cameras may
resolve 100 to 1000 fps, or
even more.

Temporal resolution is also
important for fMRI,

though instead of capturing frames (images), we are capturing brain volumes.

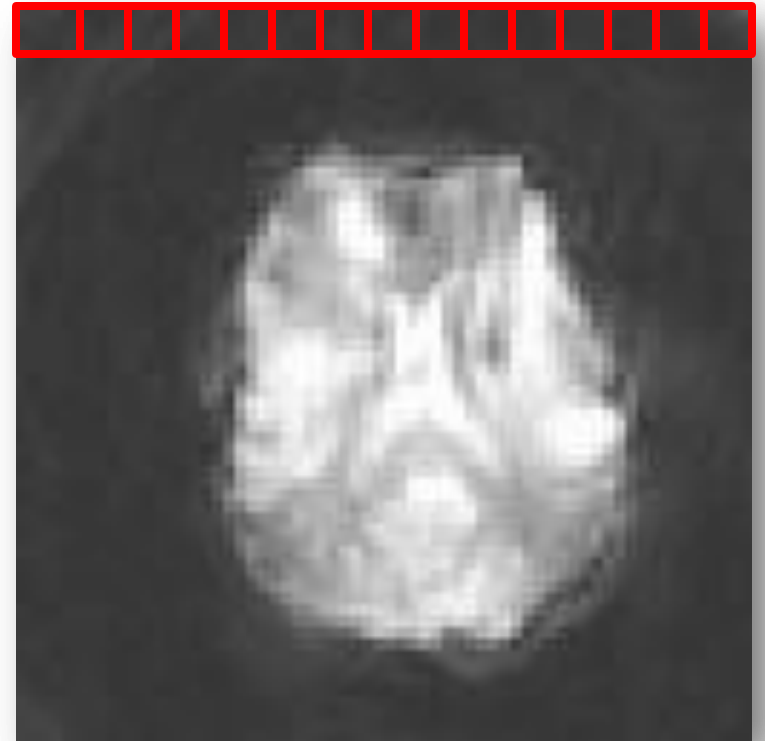
The best we can do is about
one volume every 2 seconds.

To manage this, we have to make a tradeoff between temporal resolution and spatial resolution.

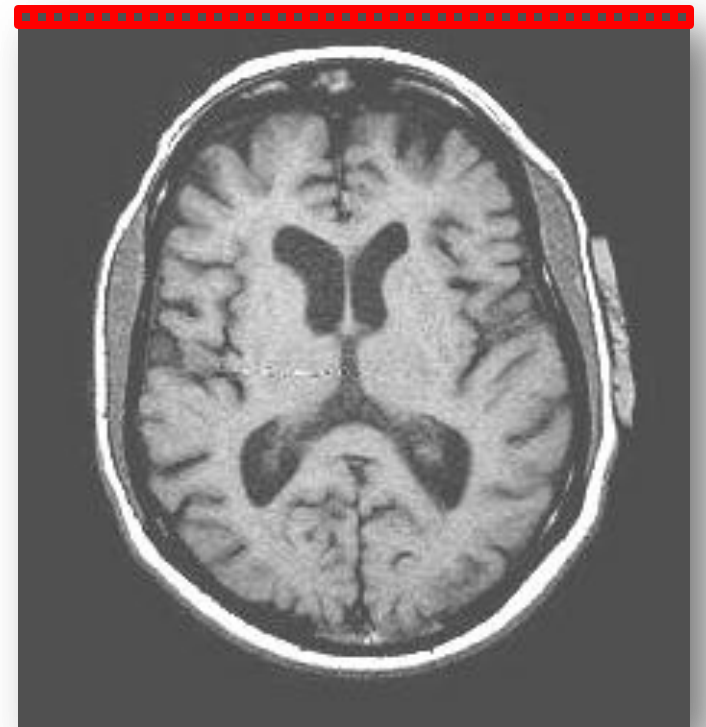
Why?

Well, imagine that you can only
capture 1000 voxels per
second.

Big voxels each
cover more
brain, so you
can capture a
whole brain
faster with big
voxels.



It takes a lot of tiny voxels to cover the brain, so it takes longer to capture a whole brain with tiny voxels.



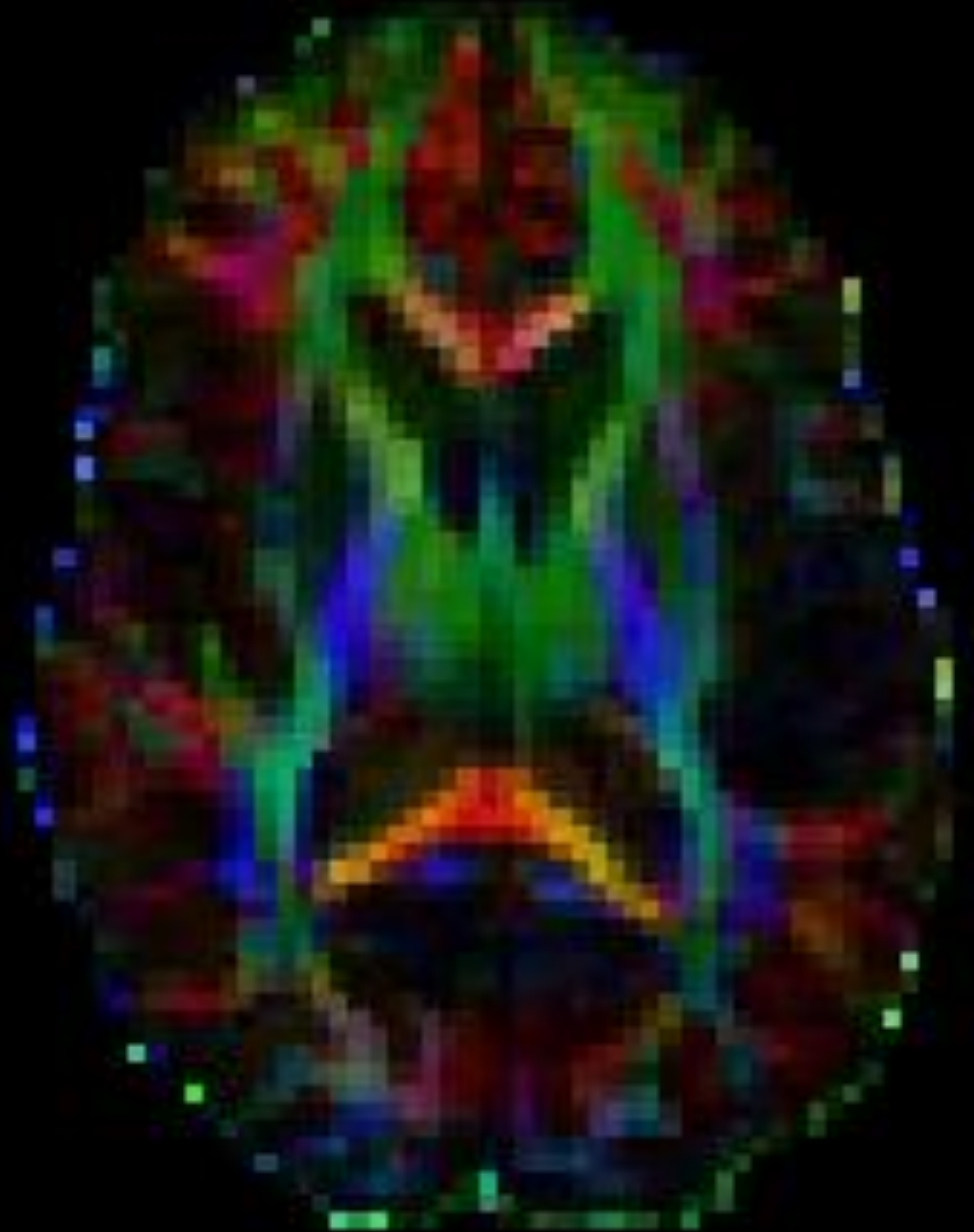
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But, fmri runs can take 10 minutes or so, because fmri is like a movie, capturing about 15-30 volumes per minute.

6) Angular Resolution

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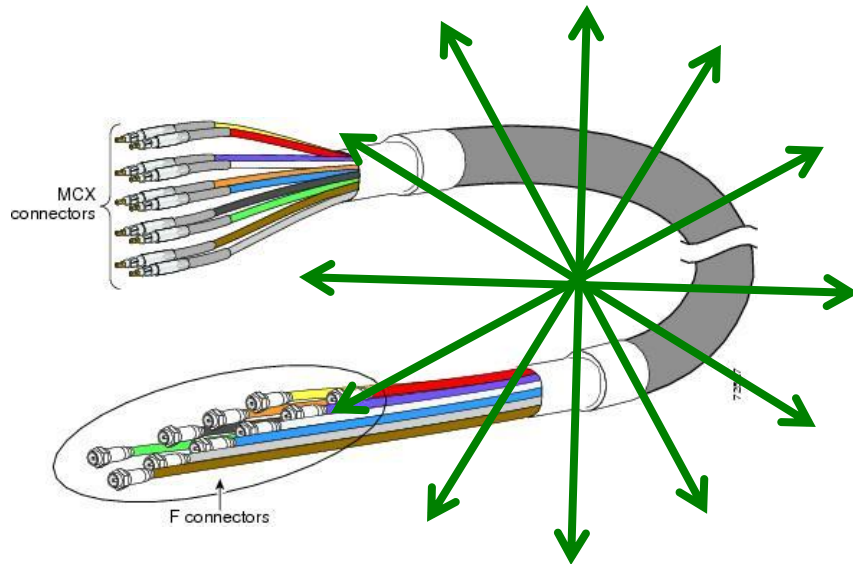
DTI tracks
the angle of
water
movement to
determine the
angle of fiber
bundles.



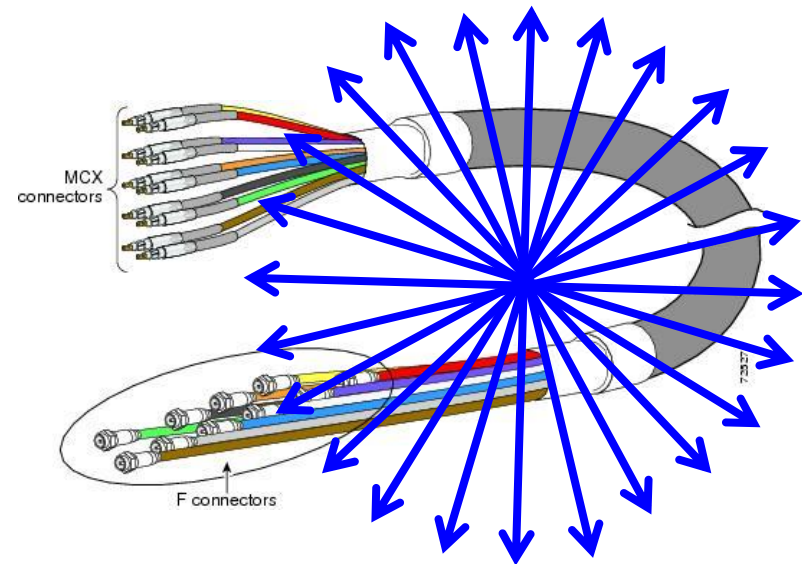
These angles can be any
direction in 3D



If we sample **more angles** through the data, then we can reconstruct tract angle in more detail.



Low angular
resolution



High angular
resolution

So, **angular resolution** is the amount of detailed angle information contained in an image.

Summary

Resolution is a multi-faceted concept which can be applied in different domains (e.g., space, time, anatomy, angle)

If you do some investigation,
you can probably find still
other notions of resolution.

No matter what the domain,
resolution always refers to
sharpness (detail).

Resolution

DPI/PPI

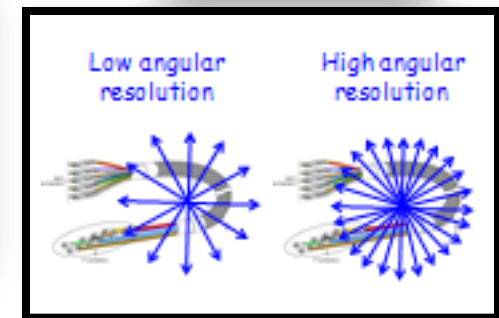
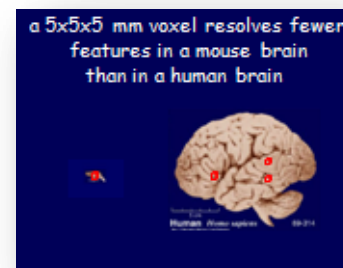
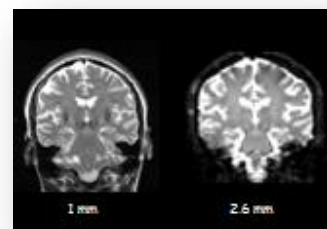
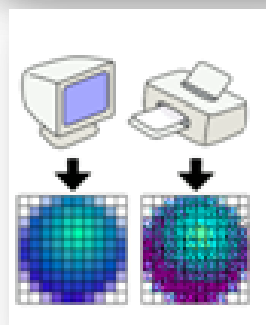
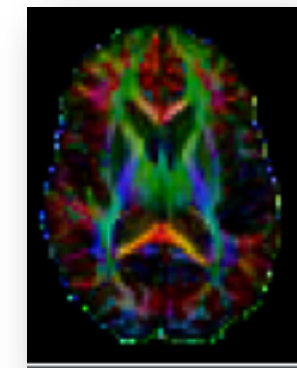
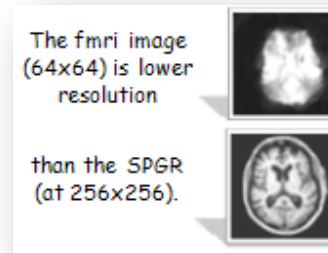
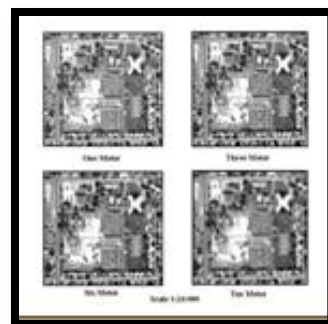
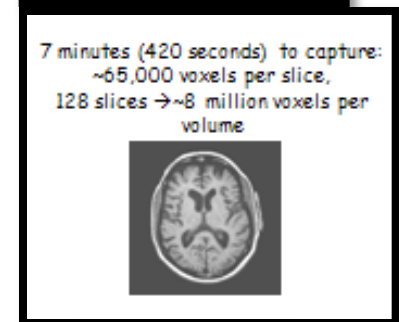
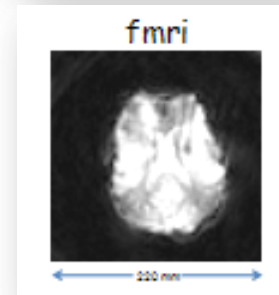
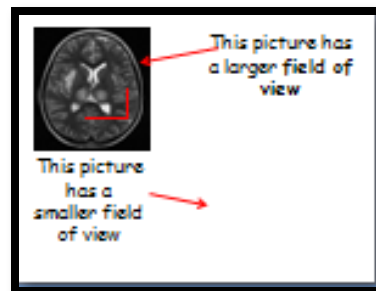
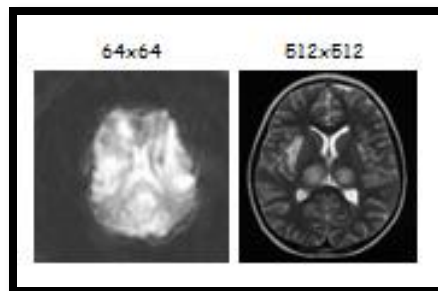
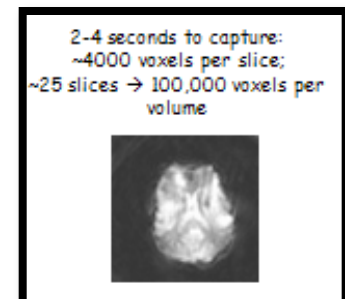
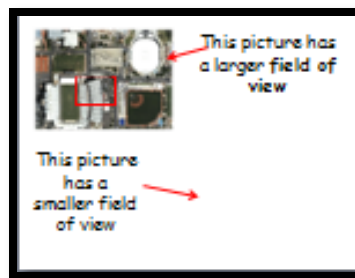
FOV

Spatial Resolution

Anatomical Resolution

Temporal Resolution

Angular Resolution



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