MiP - CSE 6108

9	12	2022

মঙ্গলবার → | 20 | 12 | 2022 |

Time: (1:30 - 4:30) pm

Room: CSE - 314, 315, 318, 405

— Registration form + ID.

Spatial memory: is a part of memory that is responsible for remembering information about the location of objects or events in space. It allows to remember the layout of room, the location of object within it. and the route we took to get there.

Cubical space: mathematical model used to represent the spatial relationships between objects. It is a type of ~~small~~ geometric space that is composed of grid of, small cubes, each representing a specific location or region in space.

In the paper, the cubical space model is used to represent the locations of objects or events in space and to study how the brain encodes and retrieves information from ~~about~~ those locations.

Spatial memory retrieval refers to the process of recalling info about the location of objects or events in space. It is is fundamental cognitive ability that allows us to navigate our environment and find our own around.

Spatial memory is typically processed by a specific part of the brain called the hippocampus, which plays a key role in spatial navigation and memory. When we need to remember the location of an object or event, the hippocampus retrieves the relevant info from our memory and uses it to guide our behaviour.

[2021
Jiahe Guo

Brain [Decoding Spatial Memory Retrieval in Cubical space]

(ব্রেন থেকে code বের করতে লাগবে)

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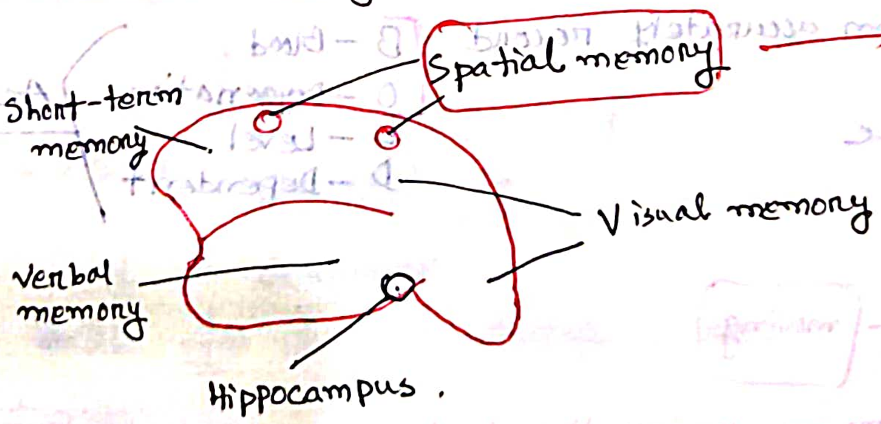
① objective
② Methods
③ Research gap / limitations / problems / Future work

Keywords specifications

Spatial memory — Storage and retrieval of information within the brain that is needed both to plan a route to a desired location and to remember where an object is located or where an event occurred.

— It is the memory that allows to remember things both on a short-term and long-term basis.



Stores info about orientation & Location

Hippocampus — The region of brain primarily associated with memory.
— Inner brain parts regulates emotional responses, involved in storing memory for long term.

— They way spatial memory / storage is represented in brain is motivating Question.

— Brain stimuli is an event or object that is received by the senses and elicits a response from a persons.

Stimulus can come in form of
- light
- heat
- sound
- touch

& form of internal factors.

brain frontal lobe is the key to auto responses to various stimuli

The primal brain has 6 stimuli —
1. personal
2. contrastable
3. Tangible
4. Memorable
5. Visual
6. Emotional.

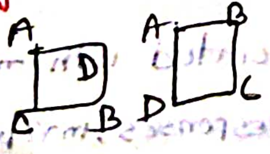
fMRI can accurately record
- B — Blood
- O — Oxygenation
- L — Level
- D — Dependent

Activity

- Exm time
- Cubical space
- EXP
- Thesis ask.

Navigation — moving

Target positions — under the table corresponding to the letters



A | B | C | D

rooms are designed to increase difficulty.

NB → SDP

Objective

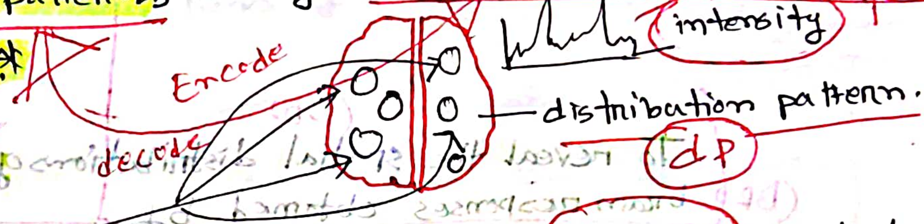
- Previous studies on the representation of navigation behaviour by signal distribution pattern but only in the hippocampus and adjacent structures.

SDP (H) (A)

- In this study, they aimed to determine

(1) The brain regions that represents information in both intensity and distribution patterns during spatial memory retrieval. (?) SMR

i, DP



(2) Whether the pattern of neural responses represent spatial memory retrieval behaviour performance.

Decode

(I) ⇒ NB → SDP (H), (A)

(II) —— aimed to determine

a) BR $\xrightarrow[\text{info}]{R}$ (i, DP) during (SMR).

b) DP $\xrightarrow{R}$ SMR behaviour performance.

?

Right handed
20 men

(1)

(2)

MRI
Data
Acquisition.

(3)

Experimental
Design

1. MRI = 3.0T MRI scanner
2. f = simultenous multislice
gradiend echo
EPIs

(4)

image processing

a. Realignment
b. spatial smoothing
c. High pass temporal filtering
d. Normalization.

(SD)

To reveal the spatial distributions of
(BR) brain responses obtained by
spatial memory retrieval (SMR)

SD (BR) ⟶ SMR

(5)

Univariate analysis
General linear model
GLM

(6)

Multivariate Pattern Analysis
MVPA

- within subject
- between subject

Performed

Correlation
analysis
to detect correspondance between
(BR) (I) Brain Responses
and
(BP) (II) Behaviour performance.

Brain area
↓↑
neural
Activity
↓↑
Spatial memory.

Spatial memory : Behavioral Data.

Methodology

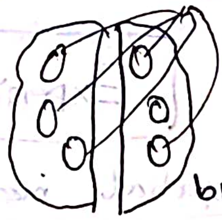
General method

1. Employed both univariate analysis
   a) General linear model. (GLM)
   b) Multivariate pattern analysis (MVPA)

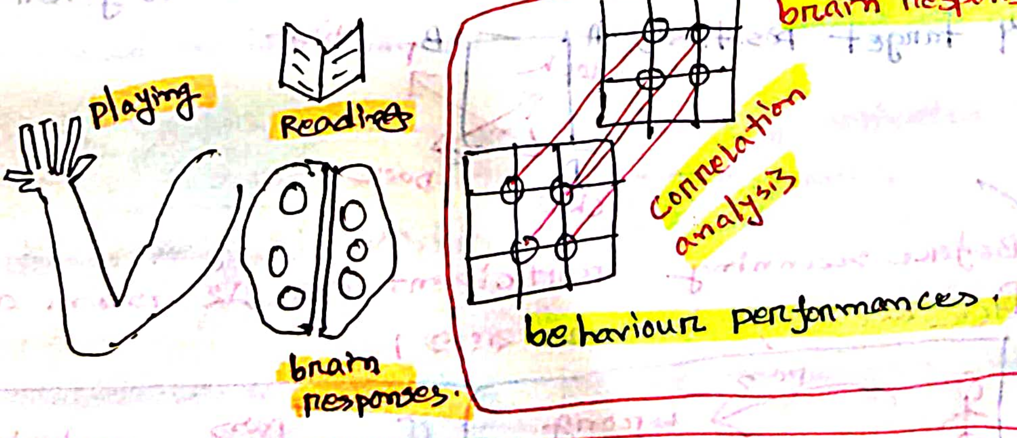
to reveal spatial distributions of brain responses elicited by spatial memory retrieval.

obtained

प्रेरित

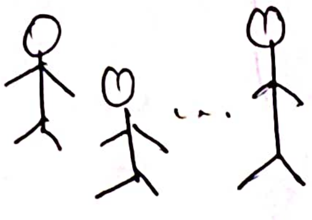


2. Correlation analyses were performed to detect the correspondence between brain responses and behaviour performance.



findings their findings have implications for understanding the separation between navigational & non-navigational ~~areas~~ states (areas) and emphasizing the utility of MVPA in the whole brain.

Twenty Men (20)



Subject

- no psychiatric or neurological illness
- All are ascertained (নিশ্চিত) to be Right handed.

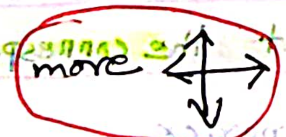
① MRI Data = 3.0 T MR. scanner

② Functional data = simultaneous multiscale gradient echo echo planner imaging sequence (EPI)

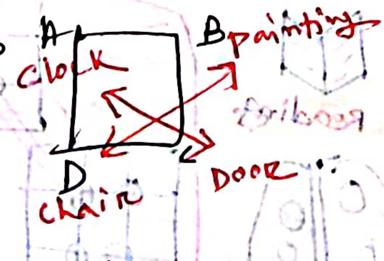
MRI Data Acquisition

Experimental Design.

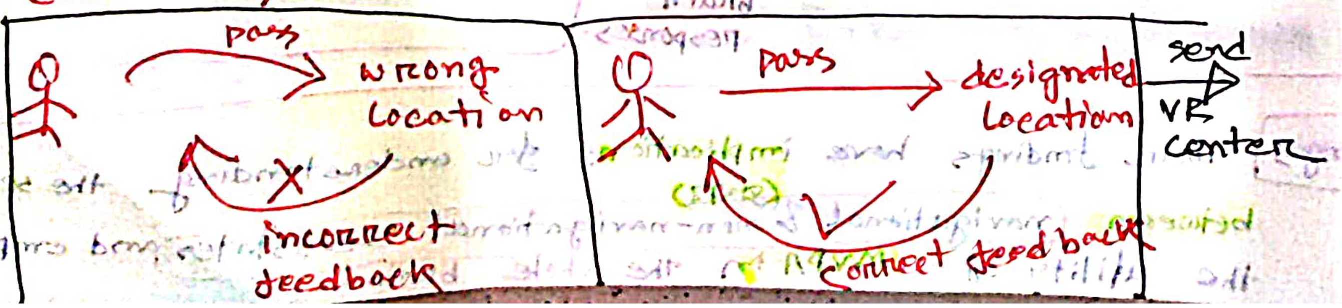
- A validate 3D spatial memory task was applied to evaluate the memory retrieval spatial locations.
- MRI-compatible response collection system with 4 buttons available for fMRI experiment.



- subject follows specific location with a given location.
- 4 target positions



Before scanning participant দের এই system a পরিচিত করানো নিচে accuracy increased করতে।



- Before poreeding, in the scanner, the subject needed to complete as many retrieval tasks as possible in 4 mins.

Image processing

- The fMRI data were preprocessed using statistical parameter mapping (SPM12)

1. Realignment: To correct the head motion-induced
2. Spatial smoothing: Gaussian kernel.
3. High pass temporal filtering: To remove low frequency noise & signal drift
4. Normalization

General Linear Model GLM

- performed GLM to identify brain areas where neural activity correlates with spatial memory tasks by contrasting the retrieval state (task phase) and non-retreival state (rest phase).
- Univariate analysis. ~~in retrevealing differences between in brain~~
- ~~activity~~. Six head motion parameters were included as covariates in the GLM.
- Average beta values within ~~gin~~ significantly activated cluster were extracted & correlated with behaviour scores.

Multivibrate Pattern Analysis MVPA.

- MVPA is considered a sensitive method to recognize the variation in brain activation
- It is a machine learning technique that uses pattern classifier to identify representational content of the neural ~~network~~

responses obtained by spatial memory retrieval.

— MVPA ~~at~~ analyzes the spatial pattern of fMRI signals across all voxels within a predefined area.

— MVPA detects condition-specific patterns of activity across many voxels at once.
whereas GLM directly compares differences in signal amplitude on a voxel-by voxel basis.

— MVPA is more sensitive than conventional GLM in revealing differences in brain activity between experimental conditions, by providing solution ~~of~~ to the problem of multiple comparisons.

— It performs a joint analysis of patterns of activity distributed across multiple voxels.

— Here, Authors applied both the
1. Within subject
&
2. between subject

MVPA

to detect spatial memory retrieval neural responses.

In both the cases, they only distinguished between navigational and non-navigational states.

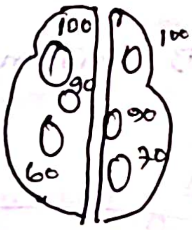
* If no specific info found then the avg classification accuracy was 50%.

Within-Subject ~~area~~ MVPA

procedure: (1) Avg BOLD signal of each trial was calculated and labeled as the task & Rest stage.

(2) The MVPA's were performed in each brain and cerebellum templates and for brain regions the BOLD signals of task & Rest trials were extacted to use as features for classification. Avg. classification accuracy for each subject were obtained.

(3)



Then the accuracy of all subjects within each brain region was fed into on sample T-tests separately to generate a T value brain MAP.

Then corresponding (P) corrected value is obtainted.

Between Subject MVPA

Procedure: (1) The beta from GLM analyses were lebeled as task & rest stage.

(2) MVPA's were performed in each brain, and for each brain region the beta values of all rest & task maps ~~were~~ across subjects were extracted and used as features for classification.

(3) This procedure repeated 1000 times.

Limitation / Research Gaps

— Previous ~~study~~ studies showed men vs Female have better performance in spatial memory tasks and different patterns of cortical activity.

(1.) But, To better explanation of how the spatial memory is encoded in the brain they recruited only male. to ensure homoginity.

✓ Sex comparisons ~~should be~~ could be significant area for future work. but that is missing here.

(2) With regard to data continuity & compatibility they collected only behavioral data. from MRI unit.

✓ Further analysis could be performed using behavioral data obtained both inside & outside MRI unit.

(3) All male were right-handed, so less data variation has seen.

Applications

(1) To determine which parts of the brain are handling critical functions.

(2) Evaluate the effects of stroke or other disease on to guide brain treatment.

(3) To detect abnormalities in brain.

$\boxed{\text{They found}}$

1. Spatial memory retrieaval occured in many arean in brain. including
   - hippocampus, Showed
   - frontal gyrus
   - parietal lobules
   - occipital lobes
   - cerebellum.

Showed significant negative correlation ($r = -0.46, p = 00$) in task completion.
" positive " ($r = 0.78, p < 0.0001$) with retrieval accuracy.

— The whole brain maps ~~m~~ spatial memory retrieval in cubical space were generated using GLM and MVPA; ~~he our~~

Result

- The posterior parietal ~~distribution~~ $\boxed{\text{cortex and rMTG}}$, are specific to spatial memory retrieval.

— MVPA provides assistance in obtaining more information about memory in the brain.

Juncheng Li - 2018

Multi-Scale ~~super resolution~~. Residual Network for Image Super Resolution

Overview

- Recenty DNN shows improved the quality of single-image super resolution (SR).
- Recent trend to use deeper network blindly, not ameliorate the network, effectively.

The increased depth of the network occured more problems in the training process.

Keywords

HR = High Resolution.

SR = super Resolution.

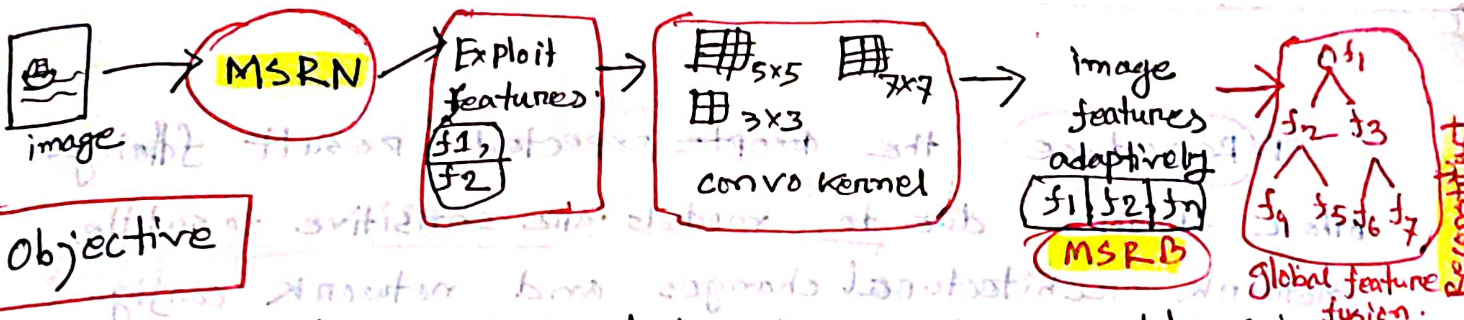
LR = Low Resolution.

MSRB = Multi-scale Residual Block

MSRN = multi-scale Residual Network.

Dataset = DIV2K.

HFFs = Hierarchical features fusion.



Objective

(1) — As increased in depth of the DNN occurs problems in training process in single image super resolution the author proposed a novel mult-scale Residual Network (MSRN) to fully exploit the features.

(2) — Based on the Residual Block they introduced different sized convolutional kernels, to adaptively detect image features.

(3) — These features interact with each other to get most efficacious image information.
This is named as Multi-scale Residual Block (MSRB)

(4) — Outputs of MSRB are used as the hierarchical features for global feature fusion

These features are used to Reconstruct High quality image.

— X —

(1) SISR aim is to reconstruct (HR) image from a (LR) image.
all the prior studies tend to construct deeper and more complex network which consumes more resources, time & tricks.
Here, The authors mainly focused to reconstruct some classic SR models Like (a) SRCNN
(b) EDSR
(c) SRResNet
to solve 3 problems from prior work.

(i) Reproduce the ~~accepte~~ expected result following other studies due to models are sensitive to subtle network architectural changes and network config.

(ii) Inadequate features utilization.

Though some authors enhanced the performance by increasing the network depth they also ignored taking full use of LR image features. These features are useful ~~to~~ for network to reconstruct ~~HR~~ High Quality image.

(iii) Poor scalability: As preprocessed LR image adds extra computational complexity & produce artifacts. Recently, more attention given to amplify LR image directly.

To solve these they proposed a novel (MSRN) model for SISR.

bottleneck layer with 1x1 kernel

Methodology

convolution layer

Image.

Aquire Image features on different scales = Local Multi-Scale

MSRB

outputs of MSRB

Output of MSRB combines = Global feature fusion.

Combination of (i) local multiscal features & (ii) Global feature fusion

can maximize the use of LR image features & completely solve the problem that features dissappear in the transmission process.

utilized a well designed reconstruction structure that is simple but efficient and can easily migrate to any upscaling factors.

- Model can (achieve more) competetive results by increasing the number of MSRB or
- The size of training images,
- The MSRB can be used for feature extraction in other restoration tasks.
- They proposed HFFS architecture and image reconstruction tha can be

① Intended to reconstruct image I^{SR} (super resolution) from I^{LR} (Low Resolution).

② $I^{LR} \xleftarrow[\text{Low Res from}]{\text{Bicubic upsample}} I^{HR}$ (High Resolution).

Bicubic interpolation is a 2D system of using cubic splines or other polynomial technique for sharpening and enlarging digital images.

Methodology

1. Image convert to YCbCr color space and train with only Y channel.

Description in Math: $(W \times H \times Y)$

for C channel in $I^{LR} = W \times H \times C$

for I^{HR}, I^{SR} $rW \times rH \times C$, C=1 means Y channel

↑ r = upscale factor.

2. Goal is to learn an end-to-end mapping function F between the I^{LR} and I^{HR}.

Given a training dataset $\{I_i^{LR}, I_i^{HR}\}_{i=1}^{N}$

~~store~~ need to slove problem:

$$\hat{\theta} = \arg\min_{\theta} \frac{1}{N} \sum_{i=1}^{N} L^{SR}\left(F_\theta(I_i^{LR}), I^{HR}\right)$$

$\theta = \{W_1, W_2, \ldots W_m, b_1, b_2 \ldots b_m\}$ weight & bias.

L^{SR} = Loss function to minimize diff. between I_i^{SR} & I_i^{HR}

widely used MSE & L2 function.

Here, they used L1 function.

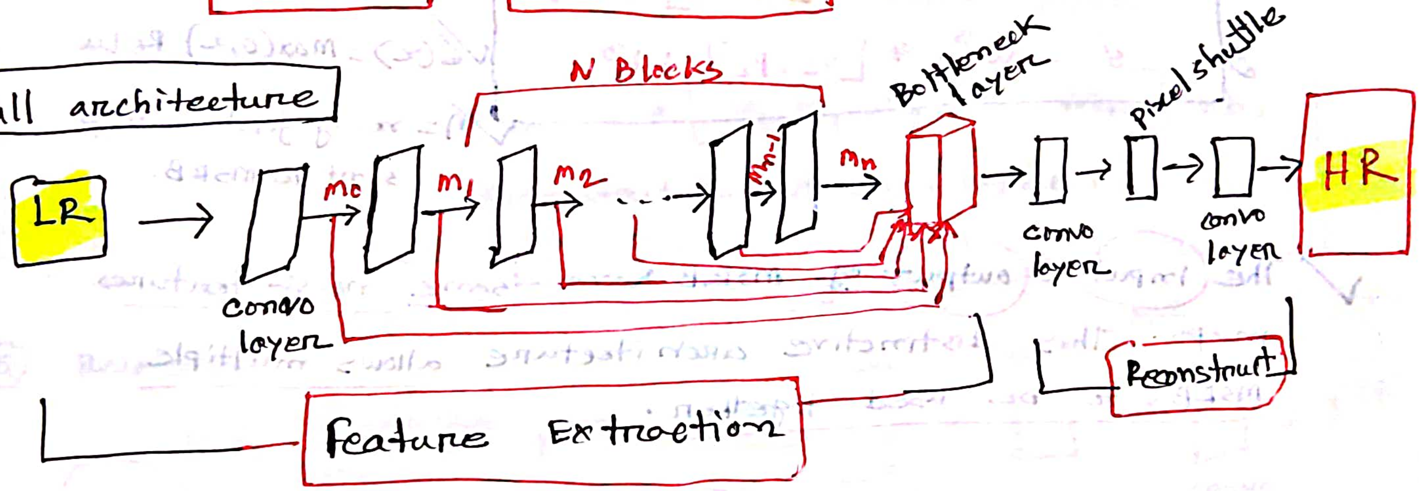
So, L^{SR} can be define as,

$$L^{SR}\{F_\theta(I_i^{LR}), I_i^{HR}\} = \| F_\theta(I_i^{LR}) - I_i^{HR} \|_1$$

Model divided into 2 parts.

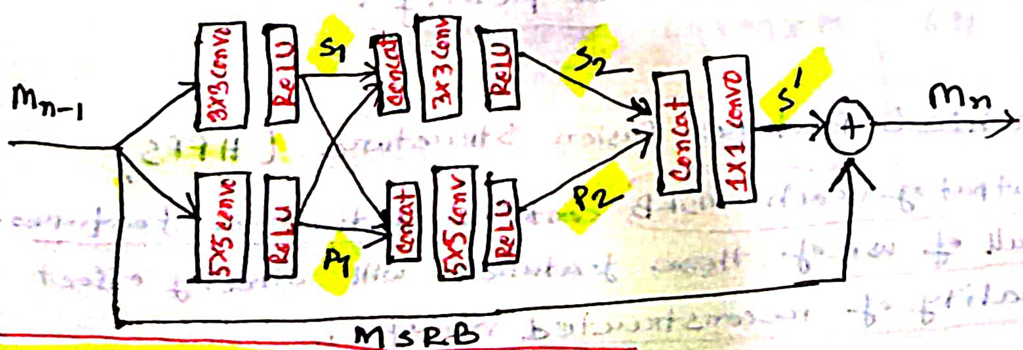
1. Feature Extraction module — unprocessed LR
2. image reconstruction module — directly upsamled to HR

Full architecture



(3) MSRB: To detect image features at different scales.

✓ Has 2 parts
(a) Multi scale features fusion (MSFF)
(b) Local Residual Learning. (LRL)



M → 2M → M features.

(a) **MSFF:** consists of a two bypass network and diff bypass use diff convo kernel.

✓ In this way info between these two bypass can be shared with each other to detect image features at diff scales.

$$1 \quad S_1 = \sigma\left(w^1_{3\times3} * M_{n-1} + b^1\right)$$
$$2 \quad P_1 = \sigma\left(w^1_{5\times5} * M_{n-1} + b^1\right)$$
$$3 \quad S_2 = \sigma\left(w^2_{3\times3} * [S_1, P_1] + b^2\right)$$
$$4 \quad P_2 = \sigma\left(w^2_{5\times5} * [P_1, S_1] + b^2\right)$$
$$5 \quad S' = w^3_{1\times1} * [S_2, P_2] + b^3$$

✓ w = weights

✓ b = bias

✓ Superscript = layers at which they are located.

✓ $\sigma(x) = \max(0, x)$, ReLu

✓ M = no. of feature map sent to MSRB.

✓ The input & output of MSRB have same no. of features maps. This distinctive architecture allows multiple MSRBs to be used together.

(b) **LRL:** In ~~ode~~ order to make the network more efficient They used Residual ~~P~~ Learning. to each MSRB.

Formally ✓ MSRB =, $\boxed{M_n = S' + M_{n-1}}$

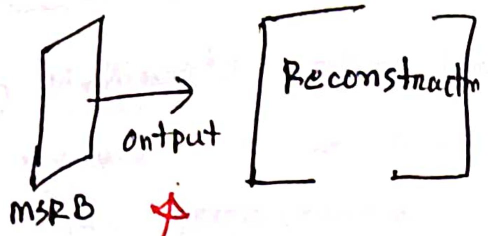
input of MSRB ... output MSRB

✓ This cuts computational complexity.

④ Hierarchical Feature Fusion Structure (HFFS)

✓ The output of each MSRB contains distinctive features. So, to full of use of these features will directly affect the quality of reconstructed image.

~~Gap / Limitations~~



Redundant features are Reduced by adaptively extract useful info.

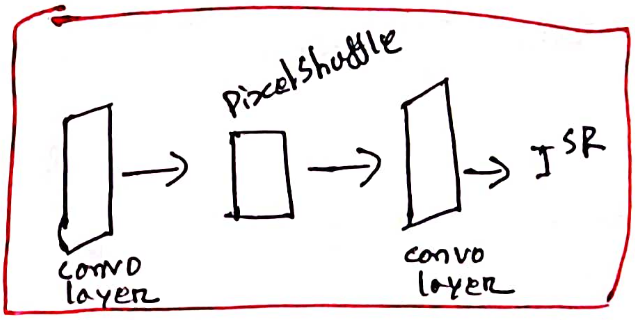
Bottleneck layer does this with (1x1) convo layer.

HFFS (output): $F_{LR} = w * [M_0, M_1, M_2, \dots M_N] + b$,

M_0 = output of 1st convo layer.

⑤ Reconstruction.

$$I^{LR} \xrightarrow[= \text{Bicubic}]{\text{upsampling}} I^{HR}$$



- This proposed module can be migrated to any upscaling factor with a minor adjustment.
- For diff. upscaling factor here only need to change the m value. following —

layer name	input channel	output channel	kernel
conv input	64	64xMxM	3x3
PixelShuffle (xM)	64xMxM	64	/
Convo output	64	1	3x3

Gap / Limitations / Future

(1) Multiscale mixed training ~~factor~~ method, geometric self-ensemble method can be used as a training tricks that can also increase model performance.

(2) Although the proposed model has shown superior performance, the reconstructed image is still not clear enough under large upscaling factors.

(3) More attention needed to large-scale downsampling image reconstruction.

Applications

1. computer vision,
2. image de-noising.
3. image - dehazing.
4. Surveillance: To detect, identify and perform facial recognition on LR images obtained from security cams.

MI

1 Intro to medical imaging.

Medical imaging (MI)

1. The overall objective of medical imaging is to acquire useful information about physiological processes or organs of the body by using external or internal sources of energy.

2. The quality of medical image depends

1 – Better X-ray image can be made when radiation dose to the patient is high.

2 – Better magnetic Resonance (MRI) images can be made when the image acquistion time is long.

3 – When ultrasound power levels are large it provides better ultrasound image.

Challanges in MI

1. Low dose to high dose image conversion (CT) L → H
2. Reconstruction image from few data (MRI)
3. Denoise / Enhance X-ray's / ultrasound image
4. Classification / Recognition / Detection of MRI bone / Tissue.

IM

MI modalities

1 R – Radiography.
2 F – Fluorocopy.
3 M – Mammography.
4 C – Computer Tomograph (CT)

X-RAY

5 – Nuclear Medicine Imaging (NMI)
6 – Single photon Emission computed Tomography (SPECT)
7 – Positron Emission Tomography (PET)
8 – Magnetic Resonance Imaging (MRI)
9 – Ultrasound imaging.
10 – Doppler Ultrasound imaging

Ultra sound

Image properties

1 – Contrast

2 – Spatial Resolution (usual picture dimension) 32x32

It is the detail pexels of an image. It measures fineness of a raster grid. Higher spatial resolutions provide clearer and more detailed images than lower resolutions.

Contrast

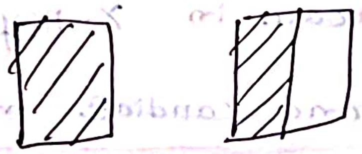
X-ray contrast is produced by differences in tissue composition, which affect the local X-ray absorption coefficient.

- Contrast in MRI is related primarily to the proton density and to relaxation phenomena.

1

2

- Contrast in Ultrasound imaging is largely determined by the acoustic properties of the tissues being imaged.



Spatial Resolution

- Resolve fine details in patient.
- Resolve = separate into constituent parts.
- The ability to see small detail and an imaging system has higher spatial resolution if it can demonstrate the presence of smaller objects in the image.
- The limiting spatial resolution is the size of the smallest object that an imaging system can resolve.

(US) - In ultrasound imaging, the wavelength (λ) of sound is the fundamental limit of spatial resolution.

From physiology to information (FP2I).

1 — Understanding image medium. (M)

2 — Physics of Imaging. (P)

3 — Imaging Instrumentation. (I)

4 — Data Acquisition methods for image info. (Da)

5 — Image processing and analysis (Pa)

(1) Understanding Image medium

— Tissue density is a static property that causes attenuation of external radiation beam in X-ray imaging modality.

— Blood flow, perfusion and cardiac motion are examples of
B P Cm
dynamic physiological properties that may alter the image of a biological entity.

(2) Physics of imaging:

The important consideration is the principle of imaging to be used for obtaining the data.

— for example, X-ray / CT imaging modality uses transmission of X-rays through the body as the basis of imaging.

— On the otherhand, in nuclear medicine modality, single photon Emission computed Tomography (SPECT) uses emission of gamma rays resulting from the interaction of radiopharmaceutical substance with the target tissue.

(3) Imaging Instrumentation.

- The instrumentation used in collecting the data is one of the most important factors defining the image quality in terms of signal-to-noise ratio, resolution and ability to show diagnostic information.

- Source specifications of the instrumentation directly affect imaging capabilities. In addition, detector responses such as non-linearity, low efficiency and long decay time may cause artifacts in the image.

(4) Data acquisition methods for image formation.

- The data acquisition methods used in imaging play an important role in image formation

- Optimized with the imaging instrumentation, the data collection methods become a decisive factor in determining the best temporal and spatial resolution.

(5) Image processing and analysis

- Image processing and analysis methods aimed at the enhancement of diagnostic information to improve manual or computer-assisted interpretation of medical images.

Know each modality

- A short history of the imaging modality.
- the theory of the physics of the signal and its interaction with tissue.
- The image formation and reconstruction process.
- A discussion of the image quality.
- The different types of equipment in use today {block diagram + implementation}
- Examples of the clinical use of the modality.
- A brief description of the biologic effects and safety issues and some future expectations.

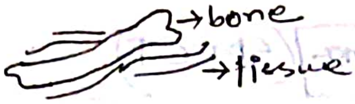
Safety

- MR and / Ultrasound which do not produce any ionising radiation
  1 2
  could perform diagnostic roles that were traditionally the preserve of x-ray radiology.
  সংরক্ষিত
- Doctor decide to request an MRI rather than an X-ray / CT or / Ultrasound ?
  1 2 3

SCS

= In general, the investigation chosen is the simplest, cheapest, and safest able to answer the specific question posed.

X-Ray



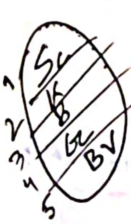
- Because of the high contrast between bone and soft tissue, the X-ray is particularly useful in the investigation of the skeletal system.

Best

- An X-ray image of the chest, for example, reveals a remarkable amount of information about the state of health of the lungs, 1 heart 2 and the soft tissues 3 in the mediastinum. (behind breast bone)

Worst

- In contrast, soft tissue organs such as the spinal cord, 1 kidneys, 2 bladder, 3 gut, 4 and blood vessels 5 are poorly ~~visibled~~ resolved by X-ray. Imaging of these areas necessitates the administration of an artificial contrast medium to help delineate the organ in question.

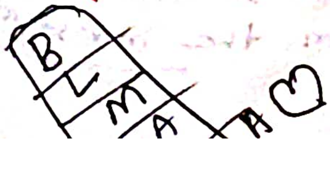


CT

- In general, CT images are only obtained after a problem has been identified with single projection X-ray 1 or Ultrasound 2 image; However, there are clinical situations (head injury) in which clinician will request a CT image as the first investigation.

Best

- CT is particularly useful when imaging soft tissue organs such as the brain, lungs, mediastinum, abdomen and with newer ultra-fast acquisitions the heart.



Gamma Imaging (SPECT)

- Like X-ray images, gamma investigations are limited by the dose related effects of ionising radiations and their spatial resolution, even with tomographic enhancement, means that they are poorly suited for the imaging of anatomical structure.

Best
- However, the technique has found an important niche in the imaging of function, that is to say, how well a particular organ is working.

- In practice, function equates to the amount of labelled tracer taken up by a particular organ or the amount of labelled blood-flow to a particular region.

- A quantitative difference in "function" provides the contrast between neighbouring tissues, allowing a crude image to be obtained.
unpurified

PET Positron Emission Tomography

- First proposed in 1950s, has taken much longer to be accepted as a clinical tool.

advantages
- While PET has a number of theoretical advantages over SPECT such as its higher spatial resolution and its use of a number of biologically interesting radio nuclides.
(1) (2)

use
- In practice, it remains a research tool, found in a handful national specialist centres, used in the investigation of tumors or heart and brain function.

MRI

use

- It has already found a particular place in the imaging of the brain and spinal cord.

- One reason is its ability to detect subtle changes in cerebral and spinal cord anatomy that were not resolvable with CT.

adv.

- The advantage of MRI over CT is due in part to the superior spatial resolution of the technique and in part to the fact that MR images are ~~spinal cord make the region difficult to image as a result of partial volume effects.~~ insensitive to bone.

In CT, ⟶

worst

- Furthermore, patients with pacemakers, artificial joints or surgical clips cannot be scanned and there are technical problems in scanning unconscious patients that require monitoring or artificial ventilation.

Ultrasound

Adv

- Is an effective and safe investigative tool. It offers only limited spatial resolution but can answer a number of clinical questions without the use of ionising radiation. Unlike MRI the equipments are inexpensive, portable and compact.

used

- Particular place i.e. imaging of pregnancy 1, also used in liver 2 and spleen 3

- Kidneys 1, pancreas 2, thyroid 3 and prostate gland 4 is also used as a screening interventional radiology.

- Plays key role in the investigation of the heart 1 and blood vessels. 2

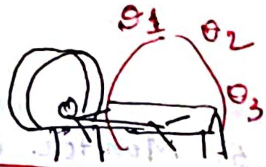
not used

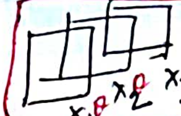
- Structures surrounded by bone, i.e. brain and spinal cord do not give clinical useful info.

- The attenuation of the ultrasound signal at air/tissue boundaries means that the technique is not suitable for imaging structure in the lung or abdominal organs obscured by gas in the overlying bowel.

	imaging	used	cant not
1	X-Ray	Skeleton system, health of lungh, heart, sof tissue	soft tissue organs i.e. spinal cord, kidney, blooder, gut, blood vessels.
2	CT (Series of X-Rays)	head injury, first investigation, soft tissue organ: spinal cord, brain, lung, mediastinum, abdomen, newer tech heart	
3	SPECT	imaging of function, How well it works.	anatomical structure
4	PET	theorotical advantage over SPECT	practical still a research to
5	MRI	Brain, spinal cord	pacemaker, antifical joint, surgical clips cannot be scanned
6	Ultrasound	Efficient, safe, pregnancy, liver spleen, kidney, pancreas, thyroid —	brain, spinal cord surround by bone

② Computer Tomography (CT)





$x_1\theta\ x_2\theta\ x_3\theta = X$

Intro

– A CT scan **combines** a series of X-rays images taken from different angles around our body and uses computer processing to create **across-sectional images** (slices) of the bones, blood vessels and soft tissues inside our body.

1 bones, 2 blood vessels, 3 soft tissues

Adv – provides **more detailed info** than plain X-rays do.

Uses

D 1. Diagnose muscle and bone disorders →
 bone
 - tumors
 - fractures.

P 2. Pin point the location
 - of a tumor
 - Infection
 - Blood clot (রক্ত পিণ্ড)

G 3. Guide procedures
 - surgery
 - biopsy
 - radiation therapy.

DM 4. Detect and monitor diseases and conditions
 - cancer
 - heart disease
 - lung nodules
 - liver masses

5. Monitor effectiveness of certain treatments

- cancer treatment

6. Detect
- internal injurgies
- internal bleeding.

Risks

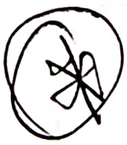
— Radiation exposer [x-rays]

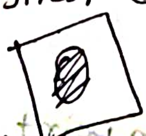
— Harm to unborn babies.

— Reactions to contrast material [Radiation dose]

Basic principles

— Mathmatical principles of CT were first developed in 1971 by Radon





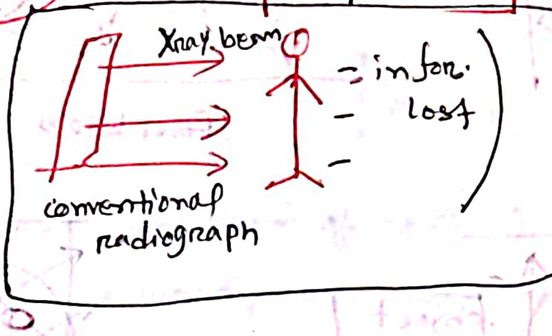
— Proved that an image of an unknown object could be produced if one had an infinite no. of projections through the object.

CT acqusition

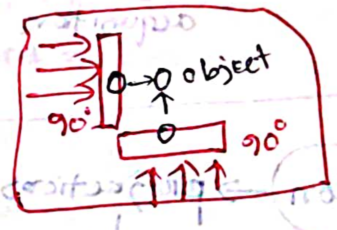
— A single transmission measurement through the patient made by a single detector at a given moment in time is called ray.

— A series of rays that pass through the patient at the same orientation is called projection.

- With a conventional radiograph, information with respect to the dimension parallel to the Xray beam is lost.



Limitations / This limitation can be overcome to some degree by acquiring two images at an angle of 90° to one another.



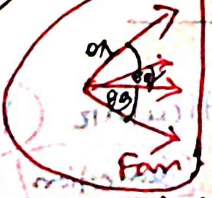
- For objects that can be identified in both images, the two films provide location information.

Acquisitions

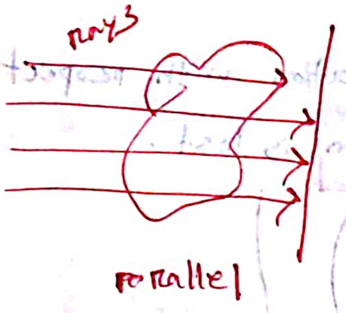
Types of projections

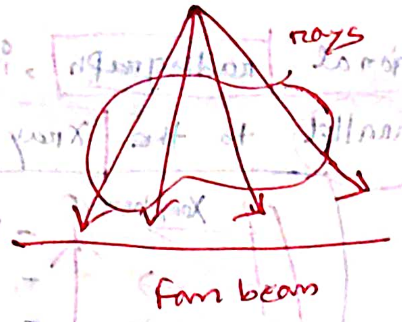
1. Parallel beam geometry - In which all of the rays in a projection are parallel to each other.

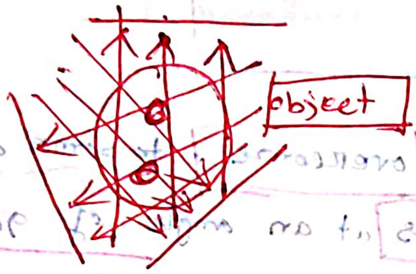
2. Fan beam geometry - The rays at a given projection angle diverge and have the appearance of a fan.



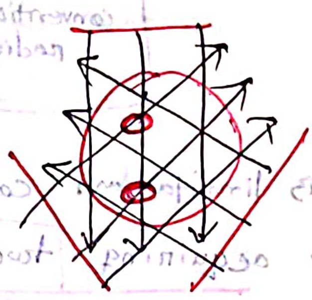
// All modern CT scanners incorporate fan beam geometry in the acquisition and reconstruction process.





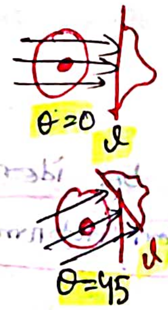


acquisition



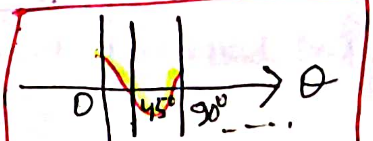
backprojection.

Radon → projections
↓
backprojections
↓
image



$g(\theta=0, l)$, 1st projection

$g(\theta=45^{\circ}, l)$, 2nd projection.

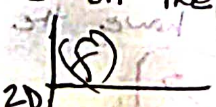


sinogram

sinogram is what is measured by a CT machine.

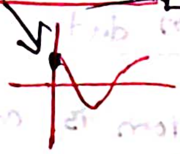
Radon Transform

- Is the Integral transform.
- which takes a function f defined on the plane to a function Rf defined on the 2D space of lines in the plane.



- whose value at a particular line is equal to the line integral of the function over that line.

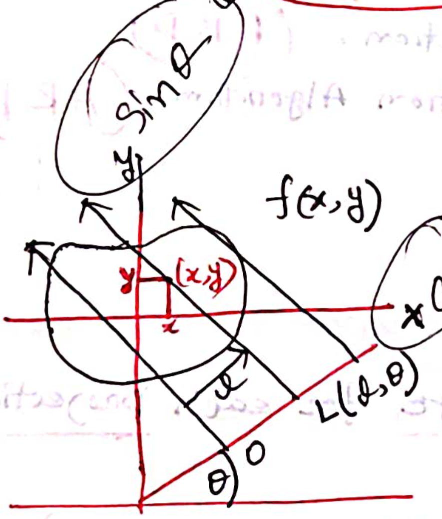
(1) — The transformed data is often called a sinogram because the Radon transform of an off center point source is a sinusoid.

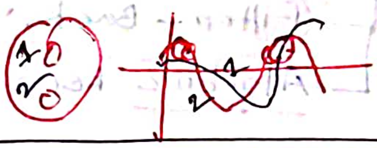


R (data) = sinogram.

off center point

(2) — Consequently, the Radon transform of a no. of small objects appears graphically as a no. of blurred sine waves with diff amplitudes and phas





In CT, we mesure $g(l,\theta)$ and need to find $f(x,y)$

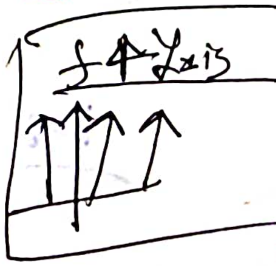
$l = x\cos\theta + y\sin\theta$.

we use,

$$g(l,\theta) = \int_{-\alpha}^{\alpha}\int_{-\alpha}^{\alpha} \underbrace{f(x,y)}_{1} \cdot \underbrace{\delta(x\cos\theta + y\sin\theta - l)}_{2}\, dx\, dy$$

$$g(l,\theta) = \sum_{0}^{M-1}\sum_{0}^{N-1} \underbrace{f(x,y)}_{1} \cdot \underbrace{\delta(x\cos\theta + y\sin\theta - l)}_{2}$$

(3) — Projections can be computed along any angle (θ). In general, the Radon transform of $f(x,y)$ is the line integral of f parallel to the y axis.



(RT) $$R(x',\theta) = \int_{-\alpha}^{\alpha} f(x'\cos\theta - y'\sin\theta,\ x'\sin\theta + y'\cos\theta)\, dy'$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

Reconstruction

— The process of reconstruction produces the image f from its projection data.

— Reconstruction is an inverse problem.

— Types of Reconstruction process:

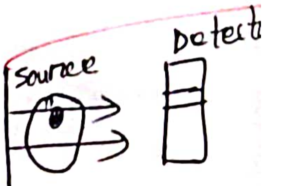
1. Back projection. (BP)
2. Filter-Back projection. (FBP)
3. Algebric Reconstruction Algorithm. (ART)

① Back-projection

1. Generate a complete image for each projection (e.g. for each angle, θ)

$$b_\theta(x,y) = g(\underbrace{x\cos(\theta) + y\sin(\theta)}_{1}, \underbrace{\theta}_{2})$$

This is: back-projected image.

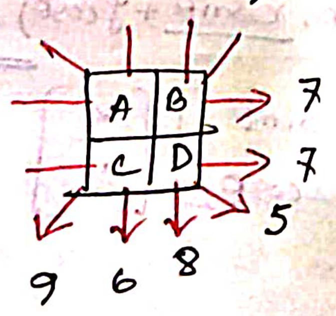


Inverse = 1 back proje

2. Add all back-projected image together.

$$f_b(x,y) = \int_0^\pi b_\theta(x,y)\, d\theta$$

Ex: Image (2x2).



problem

sums, now reconstruct value of A, B, C, D

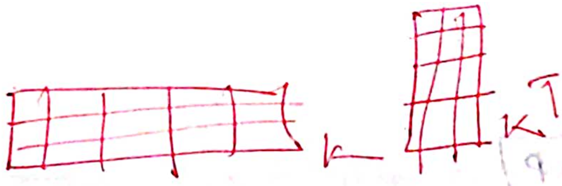
$A+B=7$
$A+C=6$
$A+D=5$
$B+C=9$
$B+D=8$
$C+D=7$

method

2	5
4	3.

solution

$A+B=7$
$\underline{-B+C=-9}$
$A-C=-2$
$\underline{A+C=6}$
$2A = 4, A=2$



③ ART

- Over-determined & non-square matrix (K) multiplied by K^T

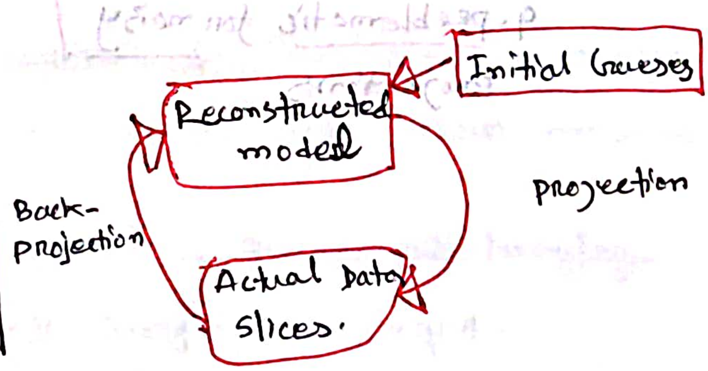
first invert square matrix.

- large problems must be solved iteratively using standard methods for solving large matrix operation problems.

$$Kx = b$$
$$\Rightarrow K^T K x = K^T b$$
$$\Rightarrow x = [K^T K]^{-1} K^T b$$

Method

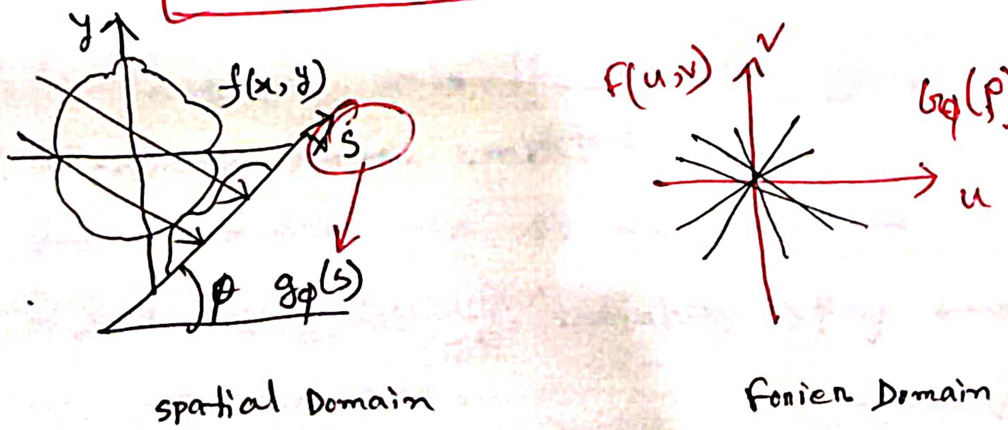
1. iterative
2. attributed to Gordon



② FBP

Method

1. Common method
2. Uses Radon transform and Fourier slices Theorem.



Works

Digital Filter

1. take 1D FFT of projection.
2. multiply by ramp filter.
3. take 1D inverse FFT
4. make a back projection.

ART vs FBP

FBP	ART
1. Filter Back progeection.	1. Algorithmic Reconstruction technique
2. Computationally cheap	2. still slow
3. Clinically usually 500 projections per slice	3. better Quality for fewer projections
4. problemetic for noisy projections	4. better quality for non-uniform project.
	5. "guided" reconstruct (initial guess).

03

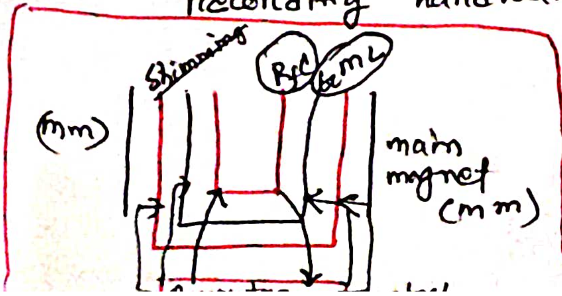
MRI Reconstruction.

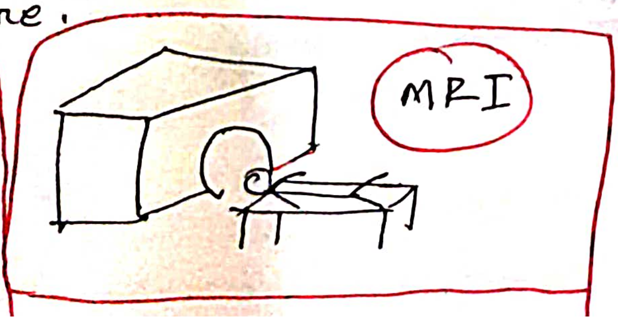
MRI

- Is an imaging technique used primarily in medial settings to produce high qualPty images of the soft tissues of the human body.
- It is based on the principles of nuclear magnetic resonance (NMR), a spectroscopic technique to obtain microscopic chemical and physical info about molecules
- MRI has advanced beyond a tomographic imaging technique to a volume imaging techinque.

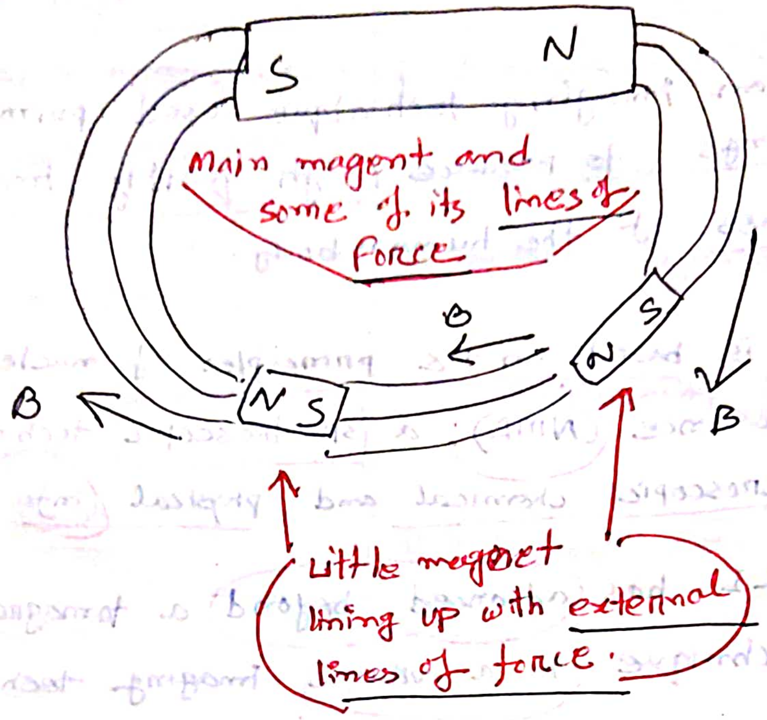
Components of scanner

- Static Magnetic Field coils : (SMC)
- Gradient Magnetic field coils (GMC)
- Magnetic shim coils (MSC)
- Radiofrequency coils. (RFC)
- Subsystem control computer. SCC
- Data transfer and storage computers (DTSC)
- Psychological monitoring, stimulus display and behavioral recording hardware.

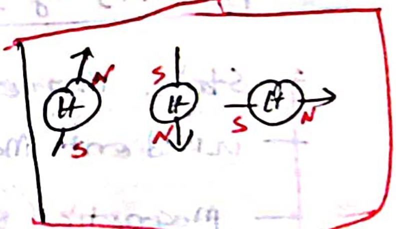




Main Magnet field



MRI Bsics



① polarized

① – All atoms (core) with an ~~ab~~ odd no. of
1, 3, 5 ~~"spin"~~ protons (H+) have a spin which leads to a magnetic behaviour.

② – Hydrogen (H) – very common in human body & very well magnetizing.

③ – Stimulate to form a macroscopically measurable magnetic field.

(2) Signal to Noise Ration (SNR) $(\frac{S}{N})$

work, adv
- proton (H+) density pictures measures H, MRI is good for tissues but not for bone.

- Signal recorded in frequency domain.

H L accurate
- Noise - The more protons per volume unit, the more accurate the measurements —
Better SNR through decreased resolution

MRI principles

- Human body composition
  - fat (F)
  - water (H_2O)

  Have many hydrogen atoms (H+)

63% is hydrogen atoms. (H+)

(2) - Hydrogen (H) nuclei have an NMR signal

(3) - MRI uses hydrogen because it has only one (H+) proton and aligns easily with the MRI magnet.

(H+)
- The hydrogen atom's proton, possesses a property called spin.

(4)
- A small magnetic field (MF)
- will cause the nucleus to produce an NMR signal.

Q NMR

- The spinning (H+) act like small, weak magnets.
- They align with the external magnetic field. (B_0)
- There is a slight excess of protons aligned with the field.
- The no. of protons (H+) that align with the field is so very ~~lage~~ large that we can pretty much ignore quantum mechanics and focus on classical mechanics.

- The spinning protons (H+) wobble or "process" about that axis of the external (B_0) field at the precessional, Larmor or resonance frequency.
- Magnetic resonamance imaging frequency (Rf)

$$\nu = \gamma B_0$$

γ is the gyromagnetic ration

- The resonance frequency ν of a spin is proportional to the magnetic field (B_0)

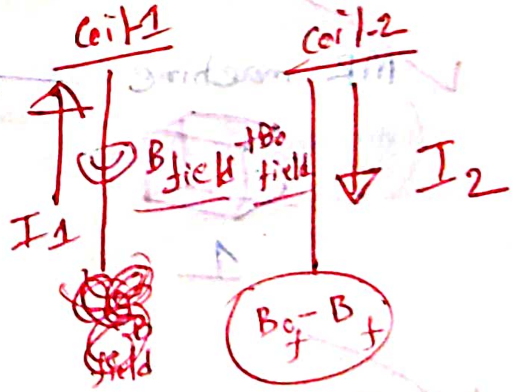
MRF, $\nu = \gamma B$

- Now, if an Electromagnetic Radio Frequency (ERF) pulse is applied at the resonance frequency, then the protons can absorb that energy and jump to a higher energy state.

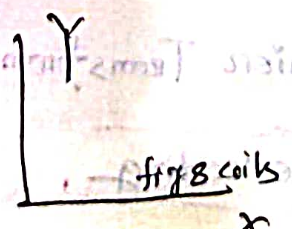
ERF → RF (↑) absorb energy → Jump High

Gradient Coils principles

- These are room temperature coils.
- Current in 2 coils flow in opposite directions creating a magnetic field gradient between 2 coils.
- The B field at one coils adds to the Bo field. while the B field at the center of the other coil subtract from Bo field.



- The X and Y gradients in the Bo field are created by a pair of figure-8 coils.



- The X axis fig-8 coils created a gradient in Bo in the X direction due to the direction of the current through the coils.
- The Y axis fig-8 coils provides a similar gradient in Bo along Y axis.

RF coils

— RF coils create the B1 field which rotates the net magnetization in a pulse sequence.

B_{1f} rotates

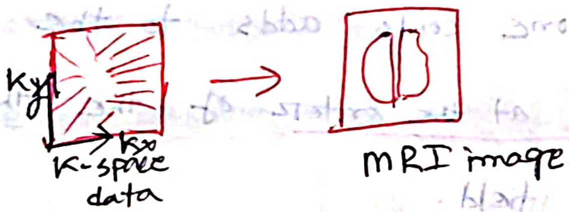
— RF coils can be divided into three (3) general categories.

(T&R) 1. Transmit and receive coils

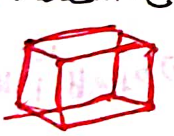
(R) 2. Receive only coils.

(T) 3. Transmit only coils.

MRI Formation



MR machine → K-space data (MR signal) → IFT → MRI Imag



1 2 3 4

Image 2D → Fourier Transform → 2D signal (frequency Domain)

1 — Gradient spatial encoding.

2 — Sampling K-space

3 — Trajectories & acquisition strategies

4 — Fast imaging

5 — Acquiring multiple slices.

6 — Image reconstruction and antifacts.

2D imaging via 2D Fourier Transform (FT)

K_{space} (raw data) $\xleftrightarrow{\text{FT}}$ Image space

spatial frequency domain

Measured MRI signal (k-space)

$$s(k_x(t), k_y(t)) = \iint M(x,y)\, e^{i2\pi k_x \cdot t \cdot x}\, e^{i2\pi k_y \cdot t \cdot y}\, dx\, dy$$

magnetization at each voxel $= (\text{image}) = \boxed{M(x,y) = \int M_{xy0}(x,y,z)\, dz}$

Sampling k-space

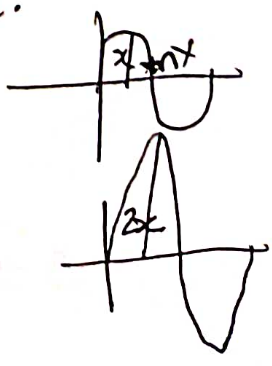
- Perfect reconstruction of an object would require measurement of all location in K-space.
- Data is aquired point by point in K-space (sampling)

Nyquist sampling

① A periodic signal must be sampled at more than twice the highest frequency component of the signal.

- A given frequency must be sampled at least

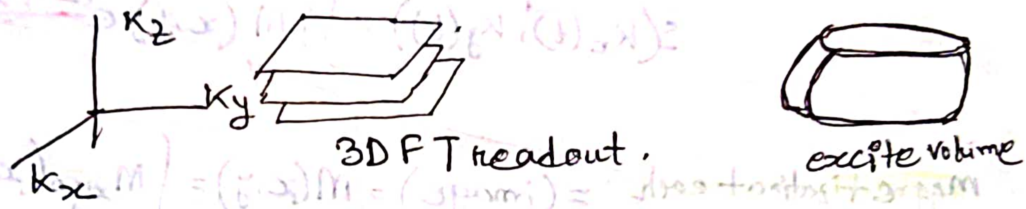
② twice per cycle in order to reproduce it accurately.



Aliasing (ghosting)

- Inability to differentiate between two frequencies makes them appear to be at same location.

True 3D imaging



✓ Repeatedly excite all slices simultaneously > K-space acquisition extended from 2D to 3D.

✓ Higher SNR than mult-slice, but may take longer

✓ Typically used in structural scans.

4

MRI construction.

— MRI is a fascinating imaging technology for capturing image to visualize inside of the human body.

Adv

1 — Painless and non-invasive procedure.

2 — Doesn't use ionizing radiation.

Invasive = কাটাছেঁড়া

MRI principle

Data acquisition → K space → IDFT → image

CT principle

Data Acquisition → Radon Transform → image

MRI	CT
1. Inherent slow data collection ├ limits spatial resolution (SR) ├ limits temporal resolution (TR) └ Introduces artifacts in image (A)	1. Radiation exposer 2. Harm to unborn babies. 3. Reactions to contrast material.
2. Moreover, slow acquisition is uncomfortable for patients. — who are anxious (A) — who are motionable (M) — limited in breath holding capacity (B) — Unco operative such a children (U)	

Motivation

MRI	CT
1. Acquisition of k-space data within reasonable time is a challenge.	1. Acquisition of projections with low dose radiation is a challenge.
2. possible solution: Enables faster acquisition by reducing sampling data.	2. possible solution: Reduces no. of projections and apply iterative algorithm to reconstruct.

These challenges can be solved using compressed sampling.

Compressed Sampling (CS)

— Compressed sampling in MRI, while reducing acquisition time, enables high subsampling factors in maintaining diagnosable image quality.

— This technique changes the goal based on 3 golden rule:

1. Incoherent sub-sampling. (SS)
2. Transform sparsity. (TS)
3. Non-linear iterative reconstruction technique. (NIR)

	Nyquist Sampling	Compressed sampling
Sampling frequency		
~~Reconstruction~~	Low pass filter	Non-linear reconstruction

Non-linear Iterative Reconstruction. (NLIR)

Basic formation of cs technique:

$$y = \varphi_c x + b$$

Objective function

$$J(x) = \underbrace{\frac{1}{2}\| \varphi_c \Psi x - y \|_2}_{1} + \underbrace{\Upsilon \| \Psi x \|_1}_{2}$$

$\varphi_c \Psi x$ generates low coherence

The goal is to achieve and optimal balance of data consistency and sparsity.

Algorithm

1. ~~Iterative algorithm (IA)~~
2. ~~Denoising & regularization based algorithm (D&R)~~
3. Werelet domain regularised based algorithm (WDR)
4. ~~Deep learning based algorithm. (DL)~~

Algo steps

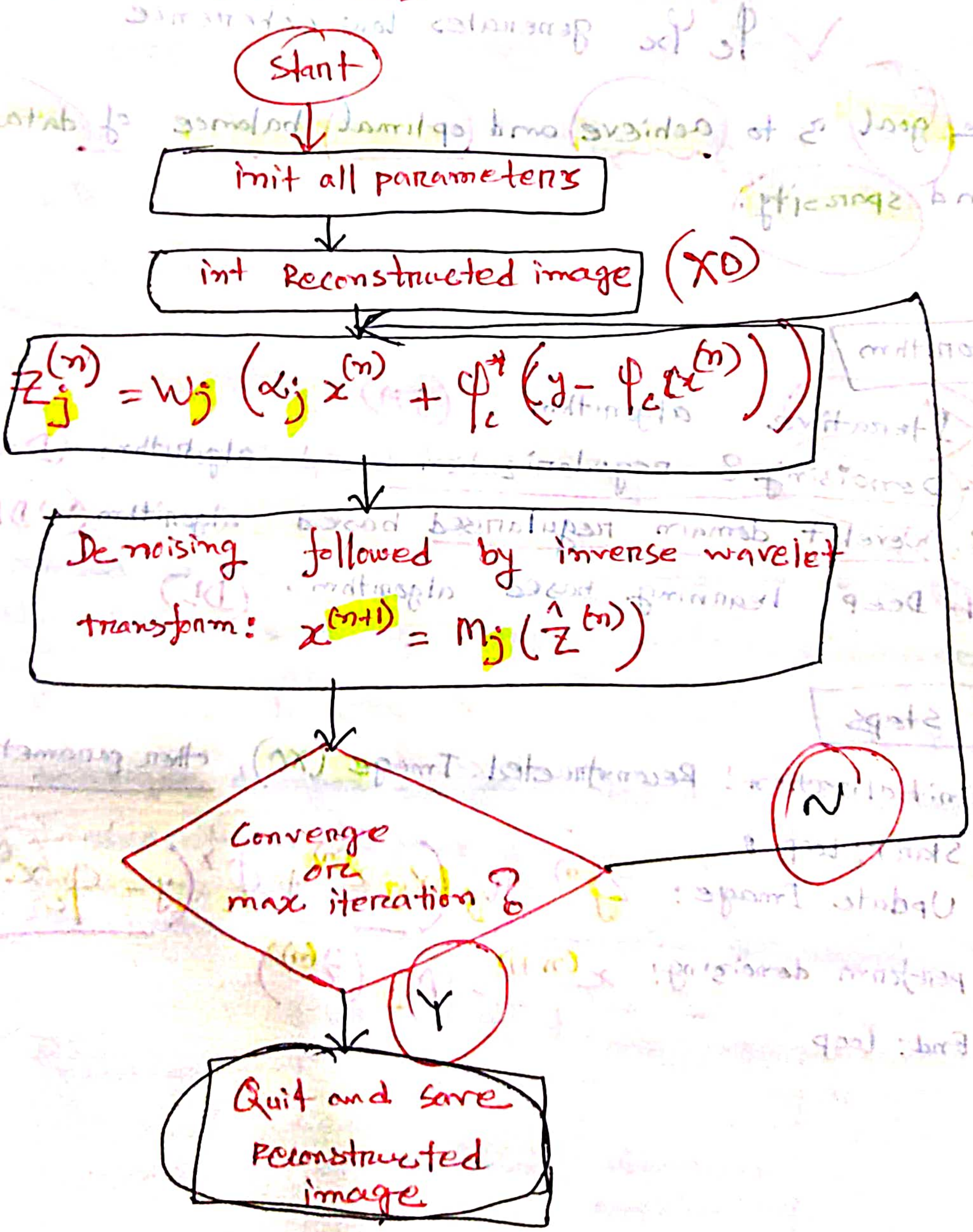
Denoising

1. initialization: Reconstructed Image (X0), other parameters.
2. Start: Loop
3. Update Image: $z_j^{(n)} = W_j \left(\alpha_j x^{(n)} + \varphi_c^{*} \left(y - \varphi_c x^{(n)} \right) \right)$
4. perform denoising: $x^{(n+1)} = M_j \left(\tilde{z}^{(n)} \right)$
5. End: loop

Denoising Algo

1. Total variation. (TV)
2. Soft-thresholding. (ST)
3. Gaussian Mixture Model. (GMM)

NLIR Flowchart



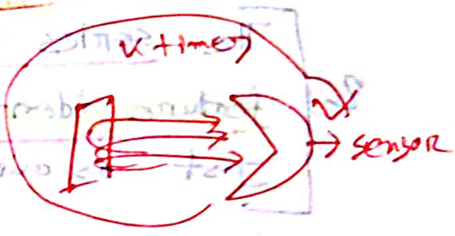
Compressed sensing (CS)

✓ Compressed sensing theory asserts that one can recover certain signals and images from far fewer samples or measurements than traditional methods use.

✓ CS relies on 2 principles:

(a) Sparsity: which relates to signal of interest (SoI)

(b) Incoherence: which relates to the sensing modality.



Signal acquisition

1. Image reflected by a mirror.
2. The reflected rays are aggregated using lens.
3. The sensor receives.
4. Measurement process repeat K times.
5. Now recover the image from the measurements.

Solving the program:

Recovery

$$\text{minimize } \|x^*\|_1$$
$$\text{subject to } Ax^* = Ax$$

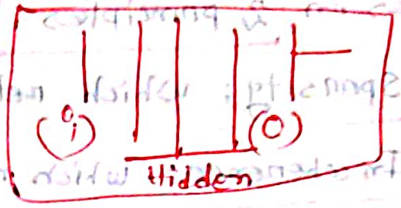
This is a linear program:

$$\text{minimize } \textstyle\sum_i t_i$$
$$\text{subject to } -t_i \le x_i^* \le t_i$$
$$Ax^* = Ax$$

DL - (8) DL for image processing

Q. What is Deep Learning? Why it is better than other methods on image, speech and certain types of data?

Ans: 1. Deep learning means using neural network (NN) with several layers of nodes between input and output.

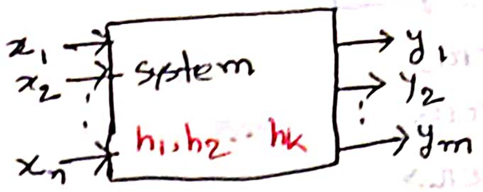


2. The series of (Hidden) layers between input and output do feature identification and processing in series of stages just as our brains seem to.

Machine learning

- ML is constructing computer programs that develop solutions (1) and improve (2) with experience.
- Solves problems which can not be solved by enumerative methods or calculus-based techniques.
- Intuition is to model human way of solving some problems which require experience.
- When the relationships between all system variables is completely understandable ML is not needed.

A generic system



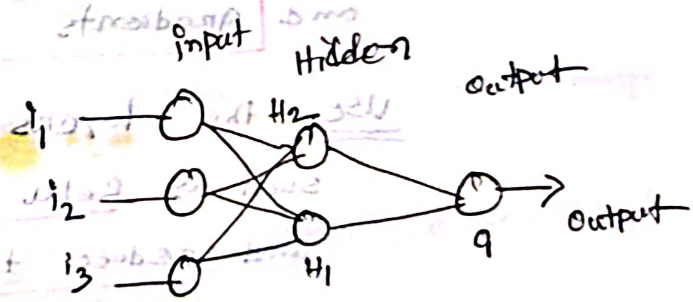
Input var $(X) = x_1, x_2, \cdots x_n$
Hidden var $(H) = h_1, h_2 \cdots h_k$
Output var $(y) = y_1, y_2 \cdots y_m$

DL application

1. Computer vision, AI
2. Image > Classification / Reconstruction / super-resolution
3. video object segmentation and tracking.
4. Activity modeling / detection / recognition.
5. Video understanding.
6. signal processing.
7. Non-linear signal processing.
8. Learned image restoration, super-resolution.
9. Learned image / video compression.

Deep learning process

✓ made up of interconnected processing elements which respond in parallel to a set of input signals given to each.



	Pretrained Network for Transfer Learning	Create a new deep learning model.
1. Training data	(100 to 1k) of labeled Images (small)	(1k to 1m) of lebeled images.
2. Computation	moderate computation (GPU optional)	Intensive computation (GPU requires for speed)
3. Training time	seconds to minutes	Days to week for real problems
4. Model accuracy	Goods depending on pretrained model	High but can overfit to small data sets.

Deep learning layers

1. Input layers
2. Hidden layers
3. output layers

① Input layers

imageInputLayer([28 28 1]) — specify Image size. here (28x28x1)
H x W x channel size

② Hidden layer (4)

1. convolution2D layer(, ,) arguments 1st arg, filter size which is the (HxW) of the filters and training function uses while scanning along the images.

2. batch Normalization Layer — normalize the activations and gradients propagation through a network.

Use this layers between convo layers and non-linearities such as ReLU layers. to speed up network training and reduce the sensitivity to network initilization.

3. ~~Re~~ reluLayer — non-linear activation function

4. maxPooling2d layer — ~~max peept~~ max pooling layer is convolutional layers (with activation function) are sometimes followed by a down-sampling operation that reduces the spatial size of the feature map and removes redundant information.

Dropout

③ Output layers (4)

1. fullyConnected layer — Here neurons connect to All the neurons in the preceding layer.

This layer combines all the features learned by the previous layer across the image to identify the larger patterns.

The last fully connected layer combines the features to classify the image.

2. Softmax layer — An activation function normalizes the output of the fully connected layer. The output consists of positive numbers that sum to one.

3. Classification layer — Uses probabilities returned by softmax function for each input.

[1,0]

Responsible for predicting class label of an input image.

4. Regression layer — Computes the mean-squared-error loss for regression problems. MSE

```
model = Sequential()                    32 filters
model.add(Conv2D(32, kernel_size(3,3), strides=(1,1), activation=
            (5)   'relu', input_shape=(28,28,1)))
model.add(BatchNormalization())
model.add(MaxPooling(pool_size(2,2)))
modeladd(Flatten())
model.add(Dense(128, activation='relu'))        # 128 units.
model.add(Dense(10, activation='sigmoid'))      # 10 units.
model.compile( ------ )
```

05 pattern recognition & Classification.

- Locate the presence of objects with bounding box and types of classes of the located objects in an image.

Input: an image with one/one more objects i.e. Brain Tumor

Output: One or more bounding boxes and a class label for each bounding box.

✓ Predict the type or class of an object in an image.

input: An image with single object such as a Tumor (Benign, Malignant)

output: A class label

✓ Application

1. Brain Tumor detection and classification from MRI/CT image.
2. Pneumonia detection from X-rays/CT
3. Covid-19 " " Xrays/CT

✓ Object Recognition Overview

object Recognition (R)
↓
image classification (C)

object Localization (L)
↓
object Detection (D)
↓
object segmentation (S)

Pattern Recognition Systems

1. pre-processing
2. Clustering and segmentation. (Kmeans + Otsu)
3. Feature extraction and reduction. (conv + PCA)
4. classification.
5. post processing.

Input → pre-processing (1) → segmentation (2) → Feature extraction (3) → classification (4) → post-processing (5) → Decision

(BSC correction)

(Kmeans / Otsu)

(Conv) PCA

(Dense)

Pre-processing

① Outlier removal (ORm)
- A point that lies very far from the mean of the corresponding random variable.

② Data normalization (DN)
- Normalizing via the respective estimates of the mean & variance
- linear technique that limits the range of [0, 1] or [-1, 1]
- softmax scaling.

③ Object smoothing. (OS) Filtering (Gaussian, Median & mean-filtering)

④ Object resizing (OR₂)

Segmentation

- Cluster with Segmentation
  - ① Kmeans
  - ② meanshift
  - ③ DBscan

  - ① centroid based
  - ②. Density based
  - ③ Distribution
  - ④. Hierarchical.
- Segmentation
  - ① Thresholding
  - ② Edge detection
  - ③ Region Growing
  - ④ Watershed
  - ⑤ multiscale

Feature Extraction

* Feature Extraction (FE)
  - Wavelet Transform (WT)
  - Histogram of oriented Gradients (HOG)
  - scale invarient feature transform (SIFT)
  - Hough transform (HT)

* Feature Reduction.
  - Independent component analysis (ICA)
  - Principal component analysis (PCA)
  - kernel (PCA)

Classification

1. Supervised classification.
2. Unsupervised "
3. Object based analysis (OBA)
4. Nearest neighbor classification, (KNN)
5. Support vector machine (SVM)
6. kernel SVM
7. Deep Learning.

Detection & Classification

(Segmentation) + (Feature Extraction) + (Classification).

S FE Cl

- Neural Network (NN)
  - CNN
  - RNN
  - FNN
  - R-CNN
  - Fast R-CNN
  - CNN-LSTM
  - GAN-CNN.

Image segmentation

- Segmentation divides an image into constituent regions or objects. and allows to extract objects in images.

Importance and Use

- After successful segmentation the image, the contours of objects can be extracted using edge detection and/or border detection techniques.

- Shape of objects can be described.
- Based on shape, texture and color object can be identified
  1 2 3
- Image segmentation techniques are extensively used in similarity searches.

Applications

1. 3D Imaging: A basic task in 3-D image processing is the segmentation of an image which classifies voxels/pixels into objects or groups.

2. 3D image segmentation makes it possible to 3D rendering for multiple objects and perform quantitive analysis for the size, density and other parameters of the detected object.
   1 2 3

3. Several application in the MRI/CT field.

Segmentation Algorithms

- Segmentation algo based on 2 basic properties of color, gray values and texture: discontinuety & similarity.

(1) — First category is to partition an image based on abrupt changes in intensity such as edges in an image.

(2) — 2nd, based on partitioning an image into regions that are similar according to predefined criteria. Histogram thresholding approach falls under this.

Gray-level segmentation:

1. Thresholding with single threshold
2. 〃 〃 a pair of threshold

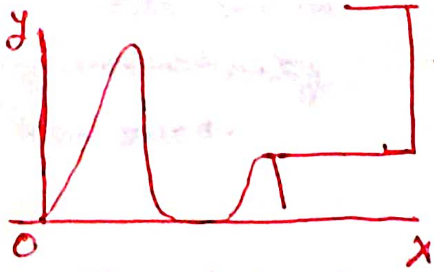
~~Gray level segmentation~~

Single threshold

- Gray-level thresholding applies to every pixel by the rule:

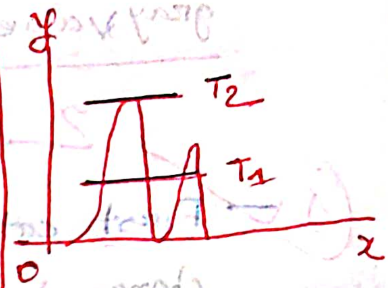
$$g(x,y) = \begin{cases} 0, & f(x,y) < T \\ 1, & f(x,y) \geq T \end{cases}$$

where, T is a threshold value



- Thresholding with a pair threshold
- Gray level thresholding using a pair of threshold value applies to every pixel by the rule:

$$g(x,y) = \begin{cases} 0 ; & f(x,y) < T_1 \\ 1 ; & T_1 \leq f(x,y) \leq T_2 \\ 0 ; & f(x,y) > T_2 \end{cases}$$



where T_1 and T_2 are two threshold value that defines a range of acceptable grey levels.

Other Segmentation tech

(i) Edge based
- point
- Line
- Edge detection.

(ii) Region based
- seeded region
- Unseeded region.
- Fast scanning.

Prewitt kernel

Verticle

-1	-1	-1
0	0	0
1	1	1

Horizonal

-1	0	1
-1	0	1
-1	0	1

diag

0	1	1
-1	0	1
-1	-1	0

diagonal

-1	-1	0
-1	0	1
0	1	1

Sobel kernel

-1	-2	-1
0	0	0
1	2	1

Verticle

-1	0	1
-2	0	2
-1	0	1

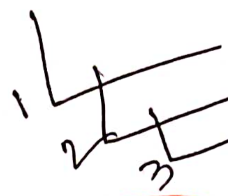
Horizontal

0	1	2
-1	0	1
-2	-1	0

diagonal

-2	-1	0
-1	0	1
0	1	2

diagonal



Canny edge detection

- Canny edge detection is a multi-step algorithm that can detect edges with noise surpressed at the same time.

Region based segmentation

Region based segmentation is a technique for determining the region directly.

Seeded Region Growing (SRG)

- Groups pixels or sub-region into larger regions.

Advantage
- with good connectivity.

Disadvantage
- Initial seed points
- Time consuming

(T)

Unseeded Region Growing (USRG)

- no explicit selection is necessary, the seeds can be generated by the segmentation procedure automatically.
- similar to SRG except the choice of seed point.

Advantage
- easy to use
- Can readily incorporate high level knowledge of the image composition through region threshold.

Disadvantage
- slow speed.

fast scanning

advantage

- very fast speed
- The result of segmentation will be intact with good connectivity.

Disadvantage

- The matching of physical object is not good.
- It can be improved by morphology and geometric mathematics.

Medical Image segmentation

- partial Differential equation (PDE) has been used for segmenting medical image.

CT

1. CT Imaging basic
2. CT image acquisition with diagram.
3. principles of back projection. techniques.
4. Filter back projection Vs algebric reconstruction.

CT

5. adv/disadv CT imaging.
6. Basic math CT reconstruction from projection.
7. Notes on parallel & fan beam.
8. Diff. among diff CT reconstruction techniques.

MRI

1. adv/dis MRI
2. Short notes on polarized tech. of MRI with diagram.
3. Reconstruction methodology of MRI
4. Evolution of MRI tech.

MRI

5. Short note on segmentations + applications.
6. Image acquisition MRI
7. Basic principles of MRI
8. proble occur when partial K-space data is used for reconstruction.

✓ modalities refer to the various techniques or methods used to create images of the inside of our body.