Knowledge Representation and Reasoning

Dr. Kalidas Y.

- **Vector Representation**

- **Vector Reasoning**

Guess!! Who is he?

Mathematical spaces

- Euclidean space

- Hilbert space

- Banach space

Mathematical Group Theory

- '+' is an 'Binary' Operator (e.g. 3+4, 0+3)
- '*' is an 'Binary' Operator (e.g. 3*4, 0*4.1)
- '-' is an Operator
  - Unary type (e.g. -3, -3.147, --7)
  - Binary type (e.g. 3-4, 9--8)
- Operand
  - A set S of elements (e.g. Real set, R)
  - The output of the operator is an operand
  - e.g. 3, -3,
- Closure property → All the outputs of operators are in S
- Special elements
  - Identity element e.g. 1 for '*' operator and '0' for '+' operator
  - Inverse element for each <Operator, Operand> pair
  - Operand = Inverse(Operator, Operand) can be thought of as operator itself!

Points in 2D - Space

- Distance between (2,3) and (-4,7)?

- Equation of line, (2,3) and (5,-6)

- Line segment, θ*(2,3) + (1- θ)*(5,-6)? (for θ between 0 and 1)

Myth: Object Oriented programming is not mathematics

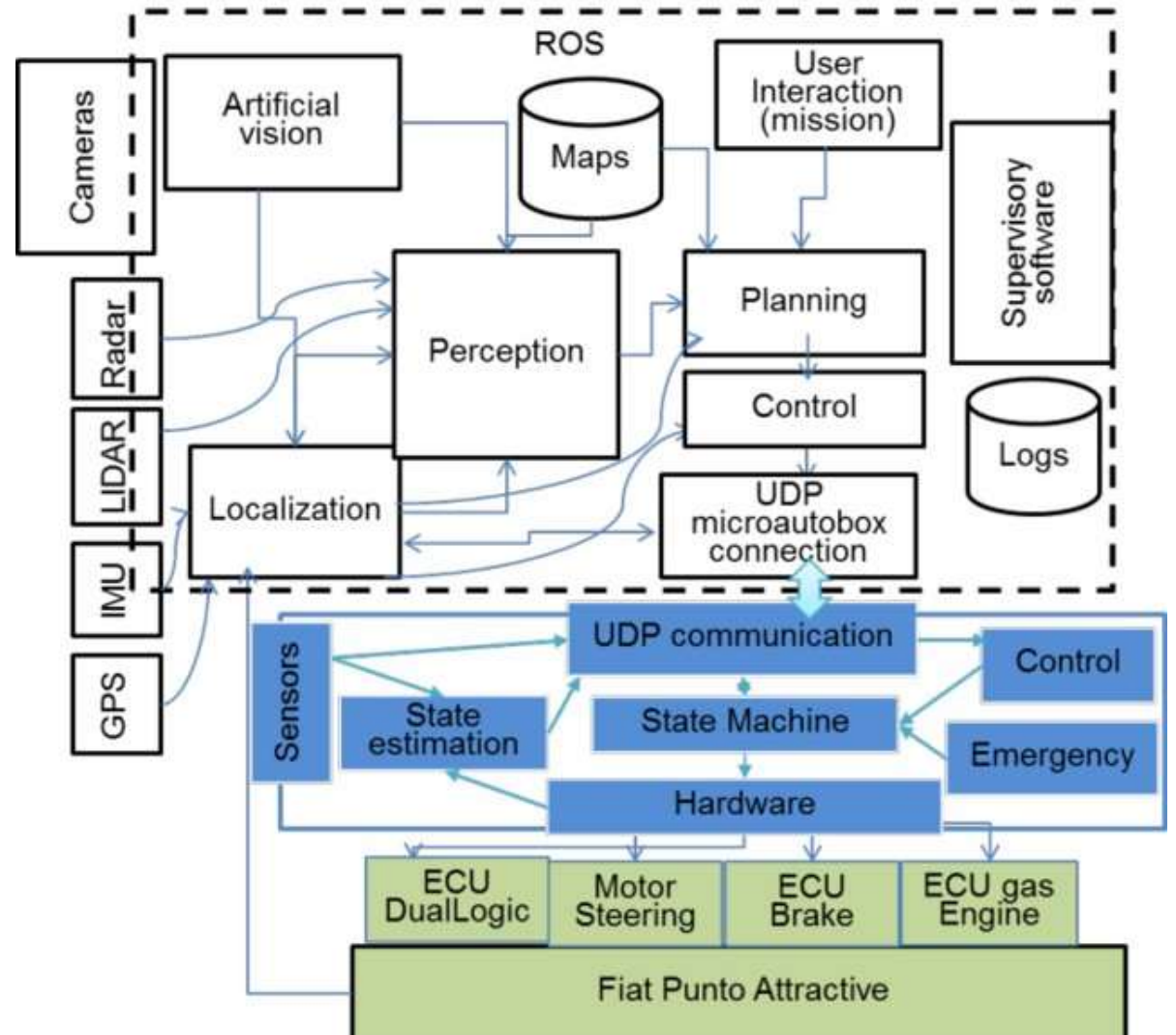| solve | $7x^9 - 14.78x^7 + 6 = 0$ |

Wolfram online editor

Results:

$x \approx -1.47259$

$x \approx 0.952624$

$x \approx 1.42858$

$x \approx -0.786762 - 0.433819\,i$

$x \approx -0.786762 + 0.433819\,i$

REF – Link here.

Ram said, "I do not think it will rain today", to Shyam. Then, Shyam said, "there is forecast for rain, let us see".

How does an object oriented thinking look like?..
What are objects here?..
What are methods here?..

Ram said, "I do not think it will rain today", to Shyam. Then, Shyam said, "there is forecast for rain, let us see".

1. Person 1
   1. p1 = PersonObj("Ram")
   2. p1.add(new SpeakerObj())
   3. p1.add(new ListenerObj())

2. Person 2
   1. p2 = PersonObj("Shyam")
   2. p2.add(new SpeakerObj())
   3. p2.add(new ListenerObj())

3. Transmitter
   1. trans = new TransmitterObj(p1,p2)
   2. trans.emit(..,..)

4. Speech
   1. speakable1 = SpeakableObj("I do not think it will rain today")
   2. speakable2 = SpeakableObj("there is forecast for rain, let us see")

5. Speaking and Hearing
   1. p1.getSpeaker().putSpeach(speakable1)
   2. trans.emit(p1,p2)
   3. p2.getListener().putSpeach(p1.getSpeaker().getSpeach())
   4. p2.getSpeaker().putSpeach(speakable2)
   5. trans.emit(p2,p1)
   6. p1.getListener().putSpeach(p2.getSpeaker().getSpeach())

How did the universe emerge?

- Initially there was nothing-object and time-object!

- There was this 'Changer-object' that changes both time and 'Any-object'

- Then, there was a Blast-object!

- Then several 'Any-object's evolved!

- Objects divided into objects, objects fused to become objects, observation became object, observed became object, operation became object and objects everywhere…

Recap

Vector Oriented Thinking and Machine Learning Problem Formulation
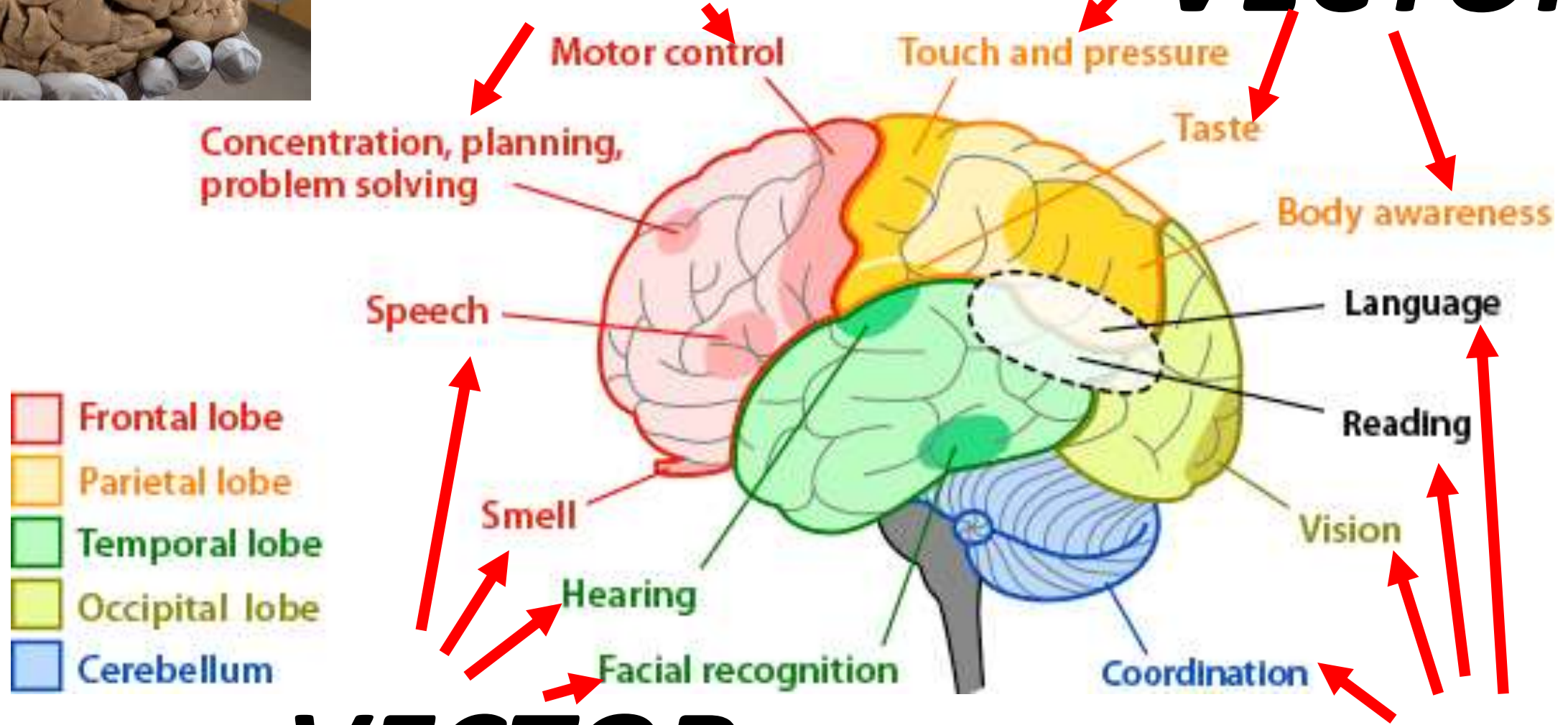
Dr. Kalidas Yeturu

IIT Tirupati

Brief abstract

Today there is a lot of buzz around artificial intelligence and machine learning. The categories of people who would want to adopt the technology span across professional domains and with varying levels of mathematical depth. In this context it is important to understand what is the underlying mechanism behind artificial intelligence and machine learning technologies. Can we just call it computational intelligence, where intelligence is defined by the programmer and the system operates according to the parameters? What is the fundamental representation of elements of intelligence? What are the data and operators? We will also see in this talk, notions data, dimensions, loss functions, bias-variance and formulation over some of the popular categories of data. The session is interactive with thought provoking mind based exercises.

VECTOR

VECTOR

VECTOR

Motor control

Touch and pressure

Concentration, planning, problem solving

Taste

Body awareness

Speech

Language

Reading

Smell

Frontal lobe
Parietal lobe
Temporal lobe
Occipital lobe
Cerebellum

Hearing

Vision

Facial recognition

Coordination

VECTOR

VECTOR

Reference – link here anyway and here.

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Scalar　Vector　Matrix　Tensor

axis 0　axis -1

Rank 4
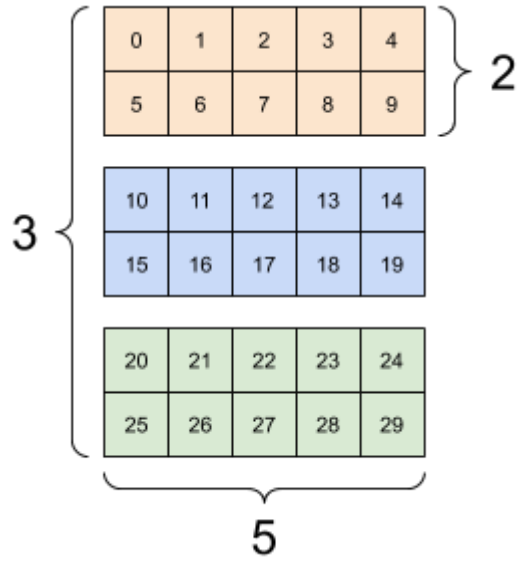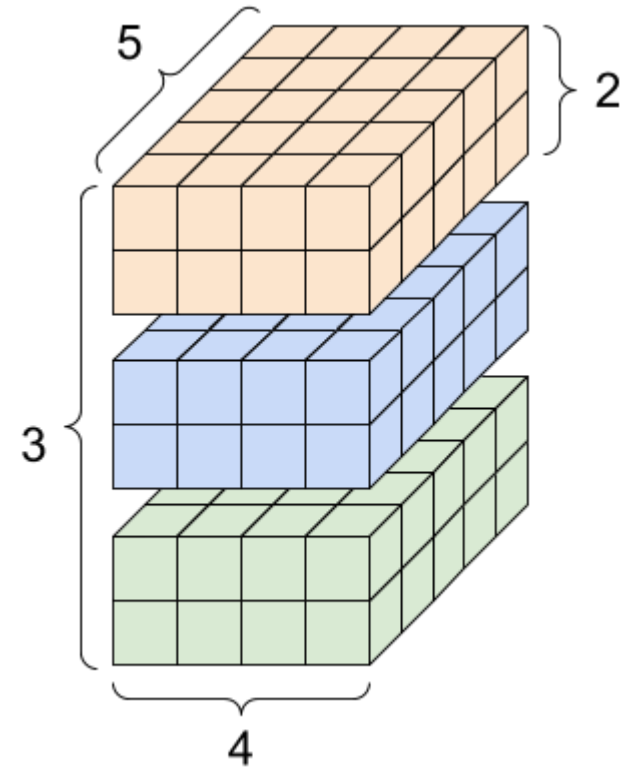
3x2x5 = 30 elements
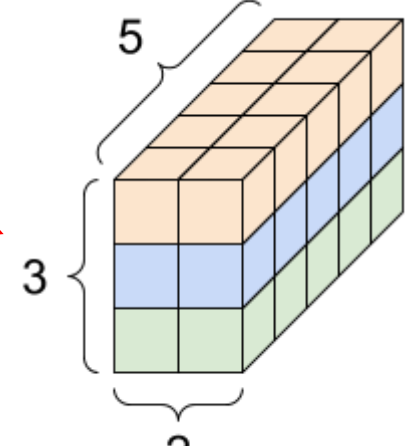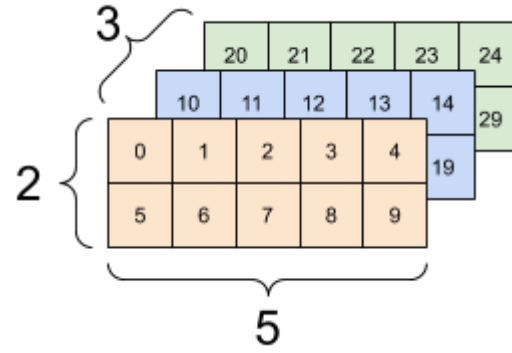
STRUCTURE OF INDEX

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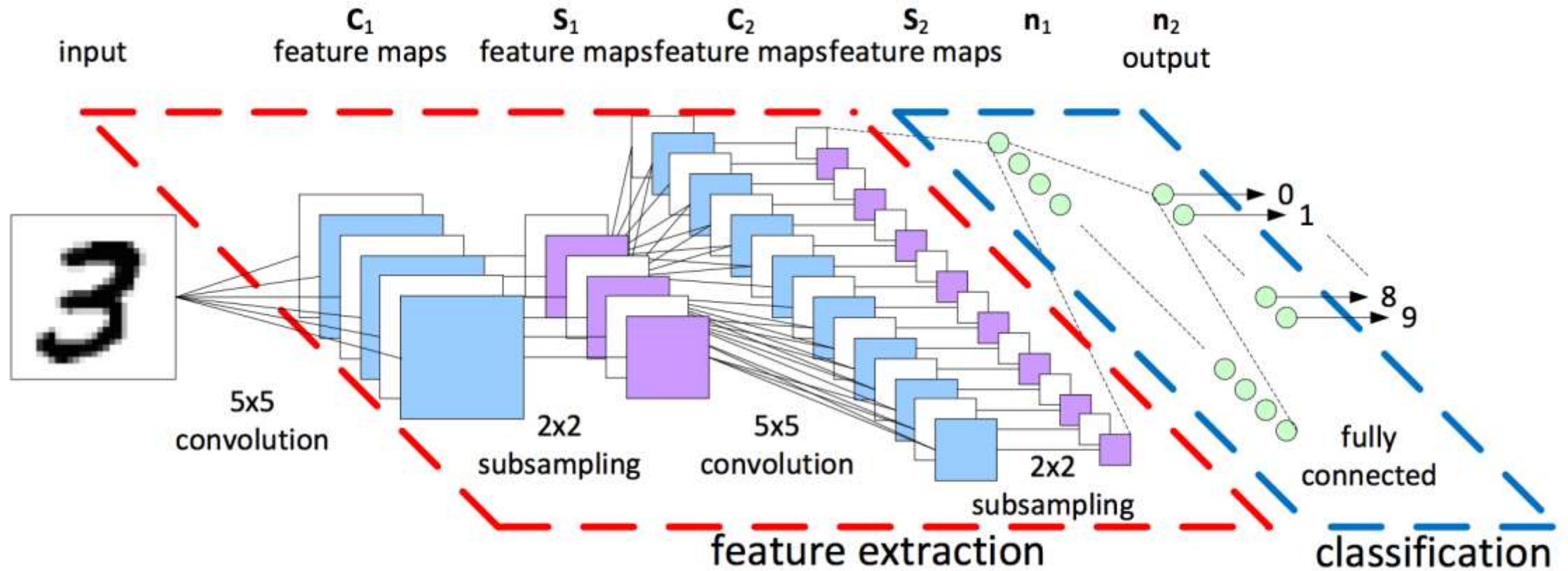
Object descriptions and *Qualitative Objects*

- How do you describe a School as an object?

- How do you describe a Computer as an object?

- How do you describe *'rude'* Behaviour as an object?

- How do you describe *'good'* Singing as an object?

Object Mapping

- Explainable
  - Movie Object
    - Actors
    - Story plot – text description
  - Genre Object
    - Setting, theme, topic, mood, budget, target audience
    - Actors
    - Story plot – text description

- Several such Movie Object → Genre Object

- Text Object -> Meaning Object (what are attributes?)

- *Not explainable* mappings(!?)
  - Map School Object to Computer Object?
  - Map Person Object to Book Object?

- Vegetable quality
  - Tomato Object
  - Tomato Quality Object
    - Good
    - Bad
      - Rotten
      - Damaged

- Face recognition
  - Face Photograph Object
  - Person Identification Object

- Photo tagging
  - Group Photograph Object
  - Marked Photograph Object – sub regions identifying who's who

- Audio clip categorization
  - Audio clip object – (amplitudes, time varying)
  - Sound category Object
    - Splash, Shout, Music
    - Loud, slow, fast

Vector Representation

- Numerical properties of an object
- Example
  - Examination
    - How many students wrote
    - When did it happen
    - What was the average mark
    - What was the standard deviation
  - Person
    - Age
    - Height
    - Weight
    - Region of stay
- Special or tricky things
- Image?
  - Pixels
  - Red, Blue, Green channels
- Video?
  - Several images, Image sequence
  - How many?
  - Concatenation of pixels of all images

- Audio?
  - At each time tick, the amplitude value
  - Number of time ticks may vary
- Text?
  - Binary vector
  - Each bit → Presence or absence of a word in the 'Vocabulary or Dictionary'
- Determine if Computer or your Cell phone is hacked?
- Determine if an equipment is working properly?
- ***Find the best match problems***
  - Cricket field to Player mapping
  - Marriage alliance?
  - Job description to Curriculum Vitae or Resume matching
  - Chatting text to State of the Mind

How to write a vectors and operators?

- Small - x
- Several vectors – X
  - Each vector is represented by X[0], X[1] etc.
  - Other representation by using sub-scripts x_i, x_j etc.
  - Sometimes people use super-scripts as well x^i, x^j etc.
    - However, it get confused 'power operator'
    - But you have to understand the context and interpret
- Vector is a matrix - $x_{K \times 1}$ which means it is a K-by-1 matrix
  - K is called 'dimensionality of the vector'
- Matrix is indicated by - $M_{K \times N}$ it is a K-by-N dimensional matrix
  - Each element of the matrix is denoted by $M[i,j]$, $M_{i,j}$, M[i][j]
  - Or rarely by superscript as well $M^{i,j}$
- The values of elements change over **time**
  - Value of vector at time t, $x^{(t)}$
  - Value of a matrix at time t, $M^{(t)}$

- Value of a matrix element at time t, $M_{i,j}^{(t)}$
- Summation
  - Elements in a vector $\sum_{i=1}^{i=N} x[i]$
  - Elements in a vector j, $\sum_{i=1}^{i=N} x_j[i]$
- Dot product
  - One vector with another $x \cdot y$
  - Specific vectors $x_i \cdot x_j$
- Products
  - Simple product $x\, y$
  - Simple product $x \times y$
  - Several elements $\prod_{i=1}^{i=N} x[i]$

Vector Reasoning

- Vector = V_{Kx1}

- Elementwise product (dot product) $dot(V_1, V_2) =$ *Similarity*
  $\sum_{\{i=1..K\}} V_1[i] * V_2[i]$

- Euclidean distance $d(P, Q) = \sum_{\{i=1..K\}} (P[i] - Q[i])^2$ *Badness*

- Matrix Transformation $Q_{K \times 1} = M_{K \times K} P_{K \times 1}$ *Transformations*

- Dimensionality Transformation $Q_{L \times 1} = N_{L \times K} P_{K \times 1}$

- Inverse, Singular Value Decomposition, Rotation and **some others..**