Finite State Machines

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Finite State Machines

Simple way to specify behaviour

Behaviour changes:

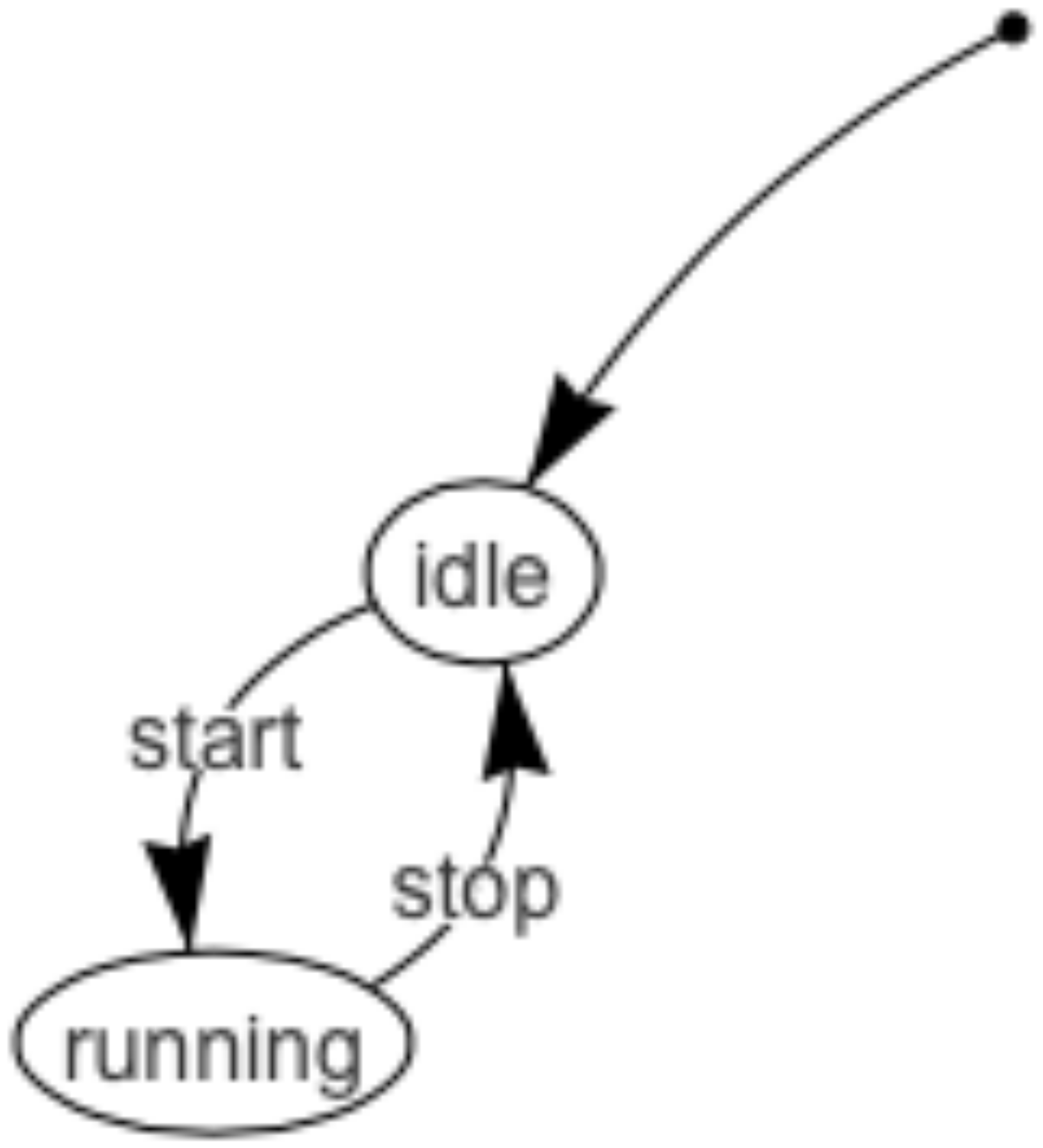
- Particular set of conditions
- Series of events

Finite State Machines

Definition

An *automaton* is the tuple $(S, E, f, \Gamma, q_0, S_m)$ where:

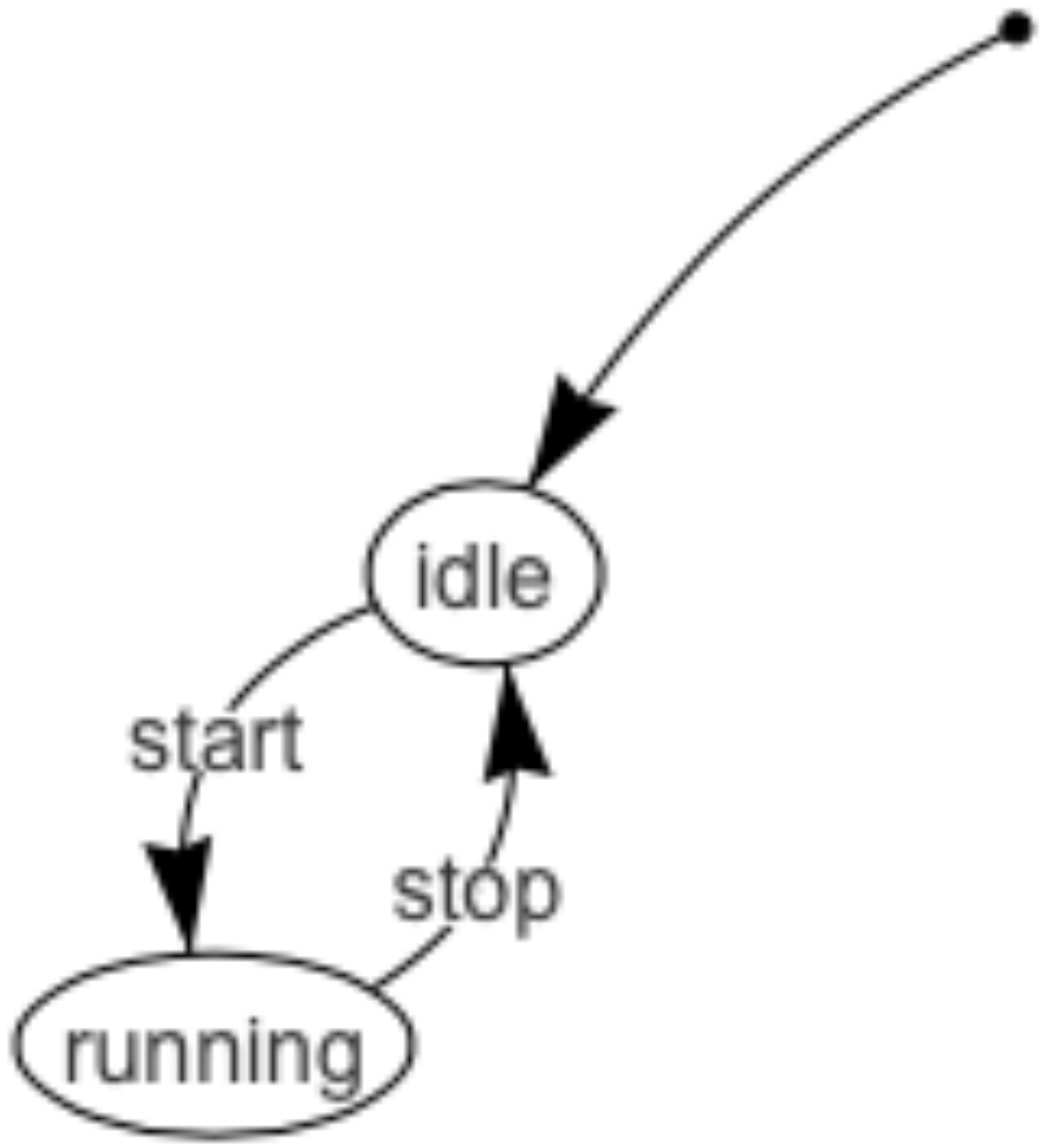
- S is a finite set of states
- E is a finite set of events (the alphabet)
- $f : S \times E \rightarrow S$ is a transition function
- $\Gamma : S \rightarrow 2^E$ is the active event function
- s_0 is the initial state



Finite State Machines

A grammar for state machines

```
FiniteStateMachine<{
    name:machine
    initial:idle
    (idle) -start-> (running) -stop-> (idle)
}>
```



Finite State Machines

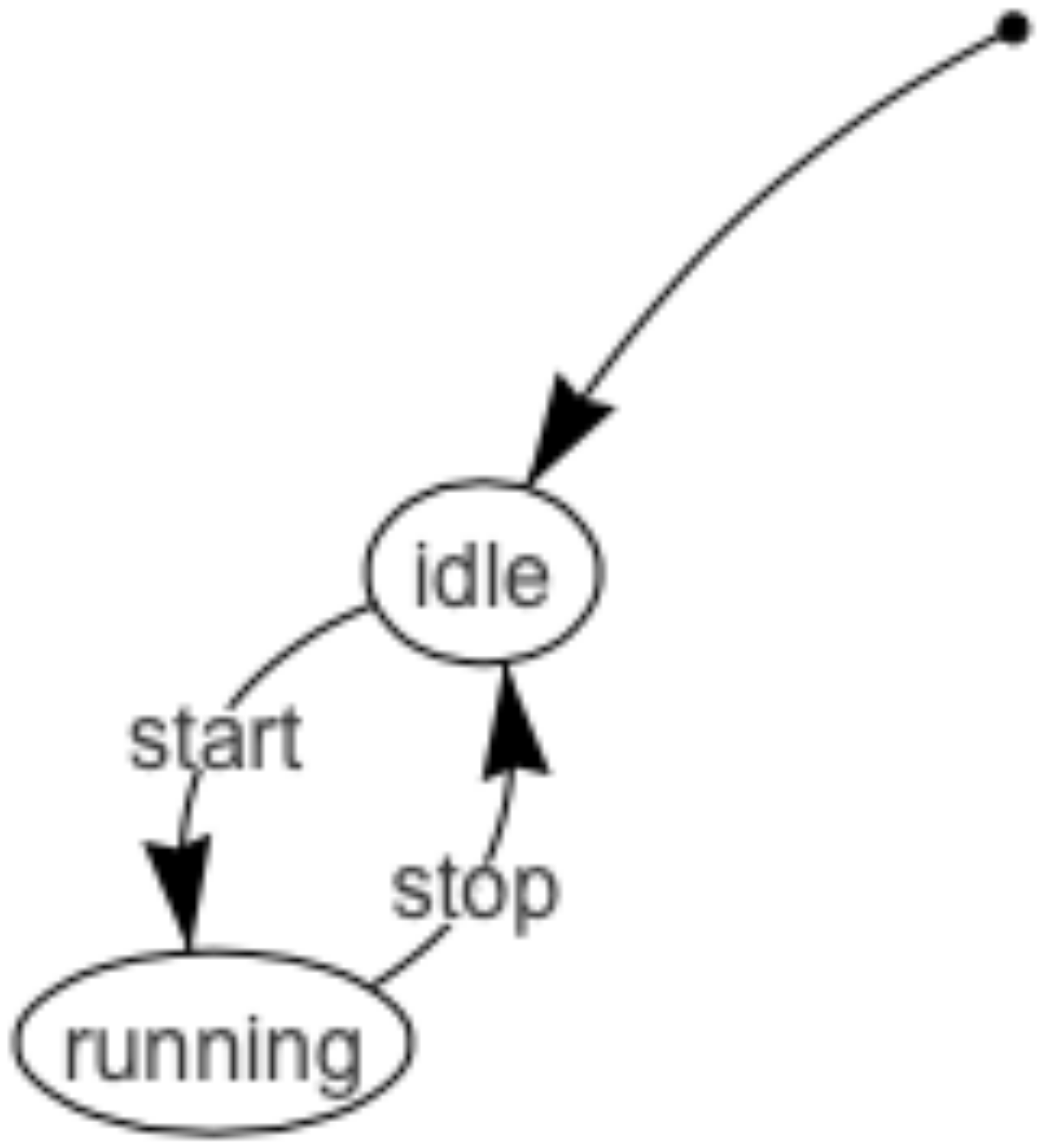
Attach callback functions

```
define entering():
   print('Transition: ', machine.lastTransition(),
              ' Entering: ', machine.state()),

define enteredIdle():
   print('Back to Idle!'),

machine.addInitFunction(entering),

machine.addInitFunction(enteredIdle, "idle")
```



Temporal logic

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Temporal Logic

Reasoning in time

$U \models \Box\phi$ Property ϕ **always** holds true globally

$U \models \Diamond\phi$ Property ϕ **eventually** holds true in the future

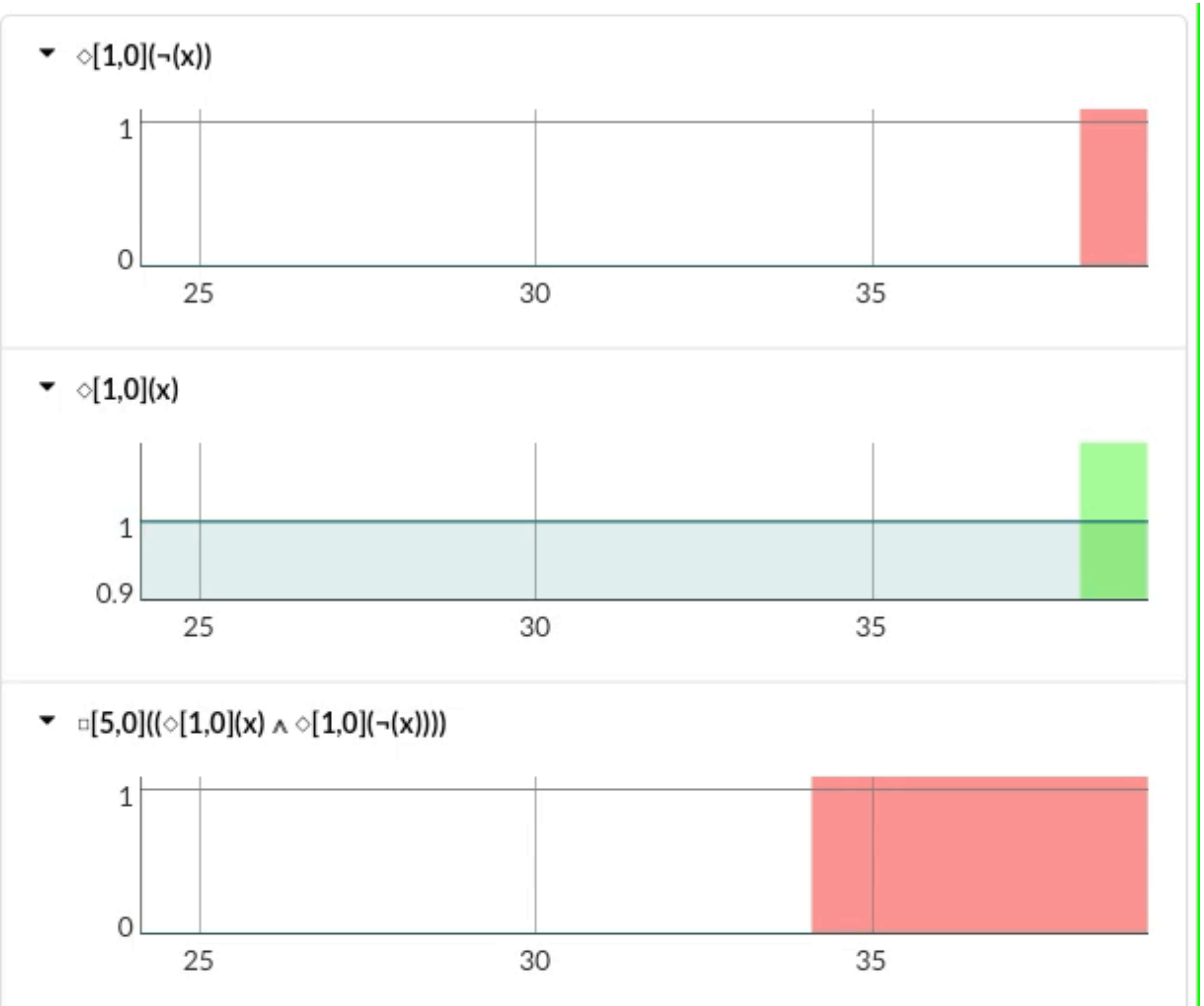
Temporal Logic

Interval temporal logic for signals

$\Box\phi[3,0]$ Property ϕ **always** held true for the last 3 seconds

$\Diamond\phi[1,0]$ Property ϕ **eventually** held true in the last 1 second

Temporal Logic



Temporal Logic

Practical examples

- If **always** in the last 5 seconds don’t have GPS update, raise an alarm
- If **eventually** any alarm raised in the last 5 second, stay alarmed

Deep Learning

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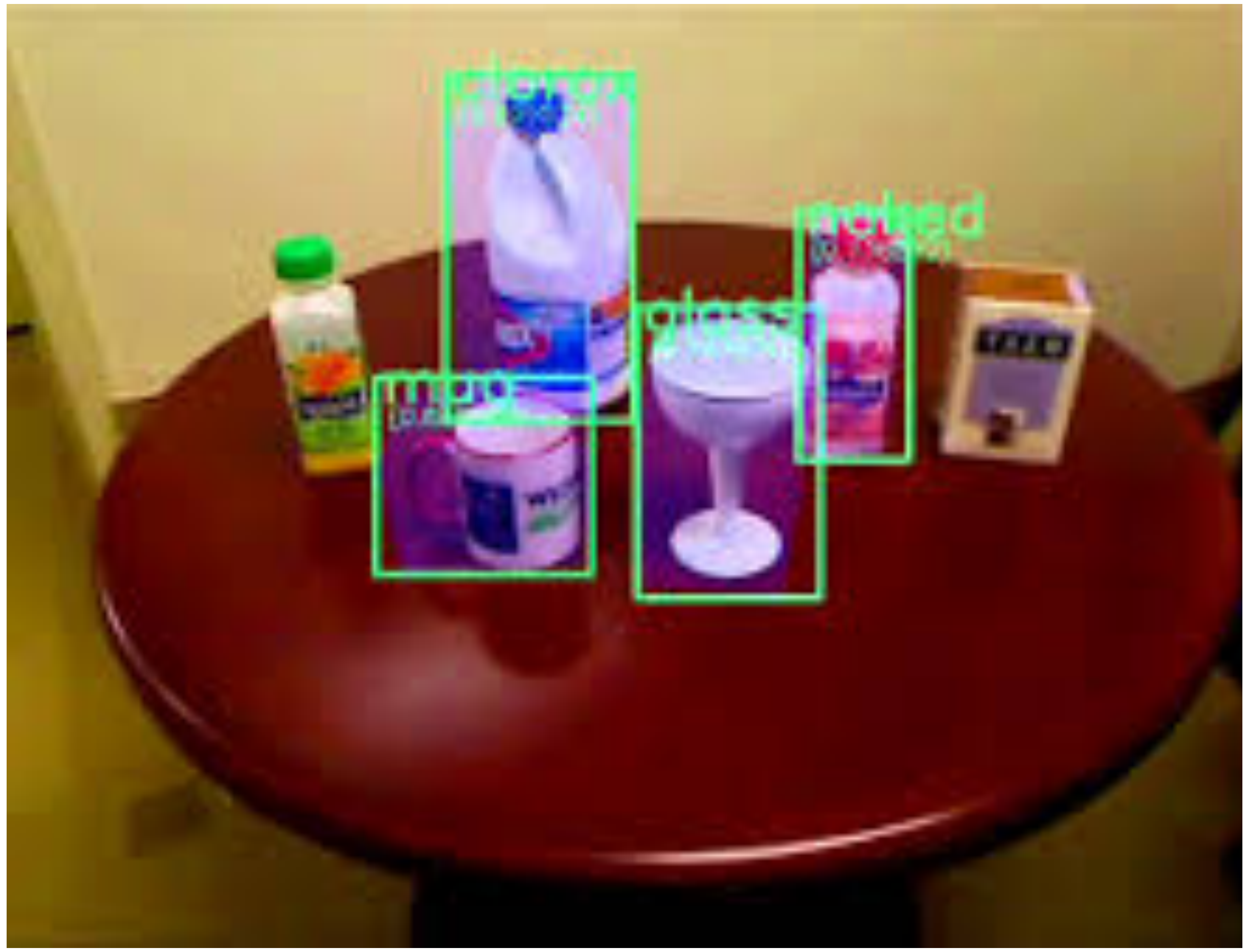
Deep Learning applications in Robotics

- Recognition Tasks:
  - Object Recognition
  - People Recognition
  - Speech Recognition
- Motion & Behavior
  - Learning motion paths
  - Task decisions



Stages of Deep Learning

Offline:

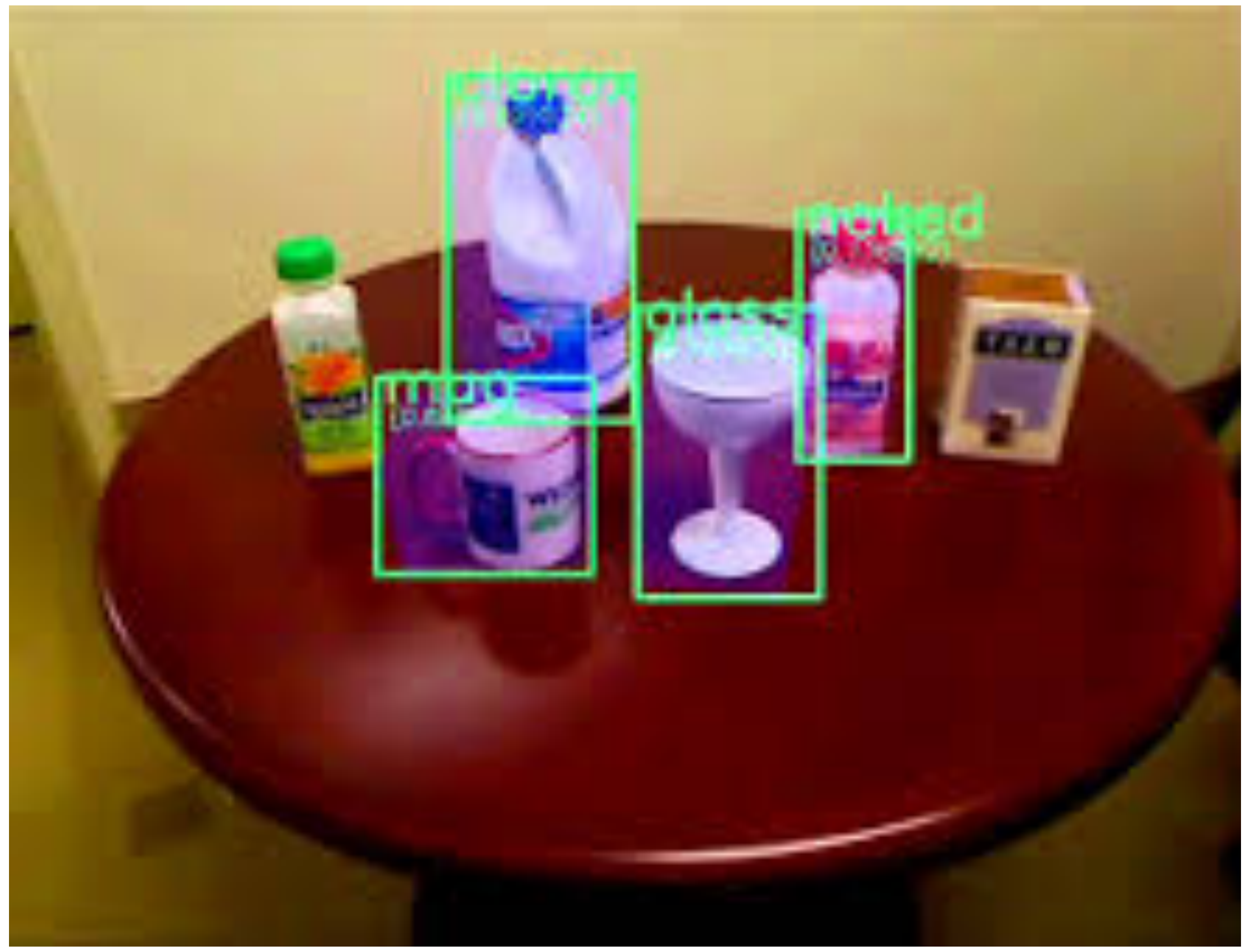
- Design
- Training
- Evaluation

Online:

- Inference
- Online training
- Data collection

Language of Deep Learning

- Object Recognition
  - Image RGB / RGBD input
  - Inference
  - Class, probability, location etc.

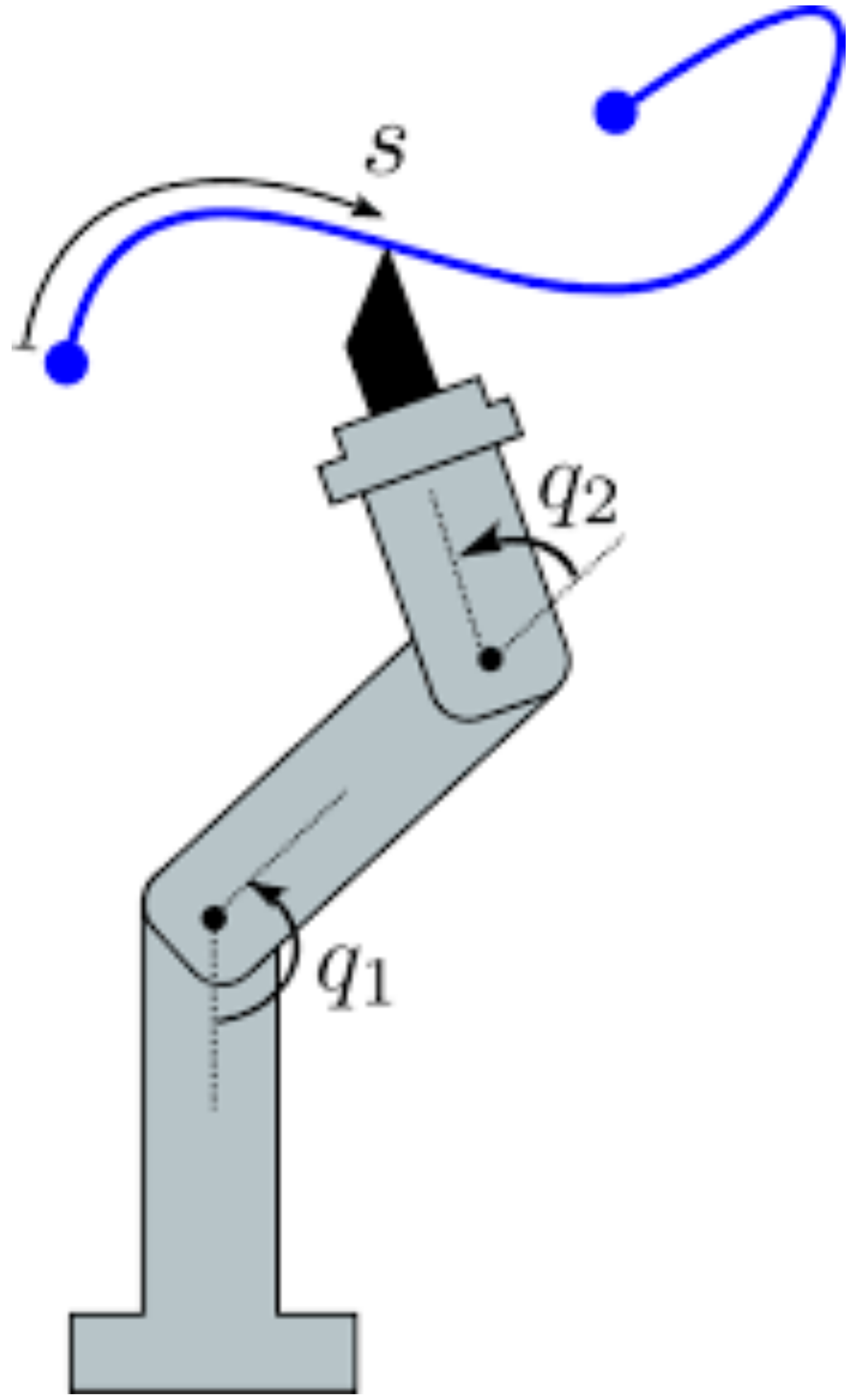


Language of Deep Learning

- Speech recognition
  - Sequence of sound (frequencies & amplitudes in)
  - Inference
  - Word(s), probabilities

Language of Deep Learning

- Motion path planning
  - Start & End positions, obstacles etc.
  - Inference
  - Speeds, Torque, energy etc.



Language of Deep Learning

abstraction

- Inference
  - Inputs
  - Inference
  - Outputs

Language of Deep Learning

minimum information

- Inputs:
  - Type
  - Format
- Network
  - Weights, architecture etc. in Tensorflow / Keras format
- Outputs
  - Type

Language of Deep Learning

- Inputs:
  - Type: sensor_msgs/Image
  - Format: 1 channel, 28 x 28 px

Creates a *preprocess* function to convert ros image topic to network input of 1 x 28 x 28.

Language of Deep Learning

- Inputs:
  - Type: audio_common_msgs/AudioData
  - Format: 1 channel, 1 x 128

Creates a *preprocess* function to convert ros audio topic to network input of 1 x 1 x 128.

Language of Deep Learning

- Outputs
  - Type: Int → Class
  - Type: Float → Probability

Creates a *postprocess* function to convert the network output to a class and probability

Language of Deep Learning

- Outputs
  - Type: std_msgs/Int → Class
  - Type: std_msgs/Float → Probability
  - Type: detection_msgs/BBox → Detection box

Creates a *postprocess* function to convert the network outputs to a class, probability and detection.

Language of Deep Learning

- Outputs
  - Type: std_msgs/String → words
  - Type: std_msgs/Float → Probability

Creates a *postprocess* function to convert the network outputs to words and probabilities.

Fault Detection

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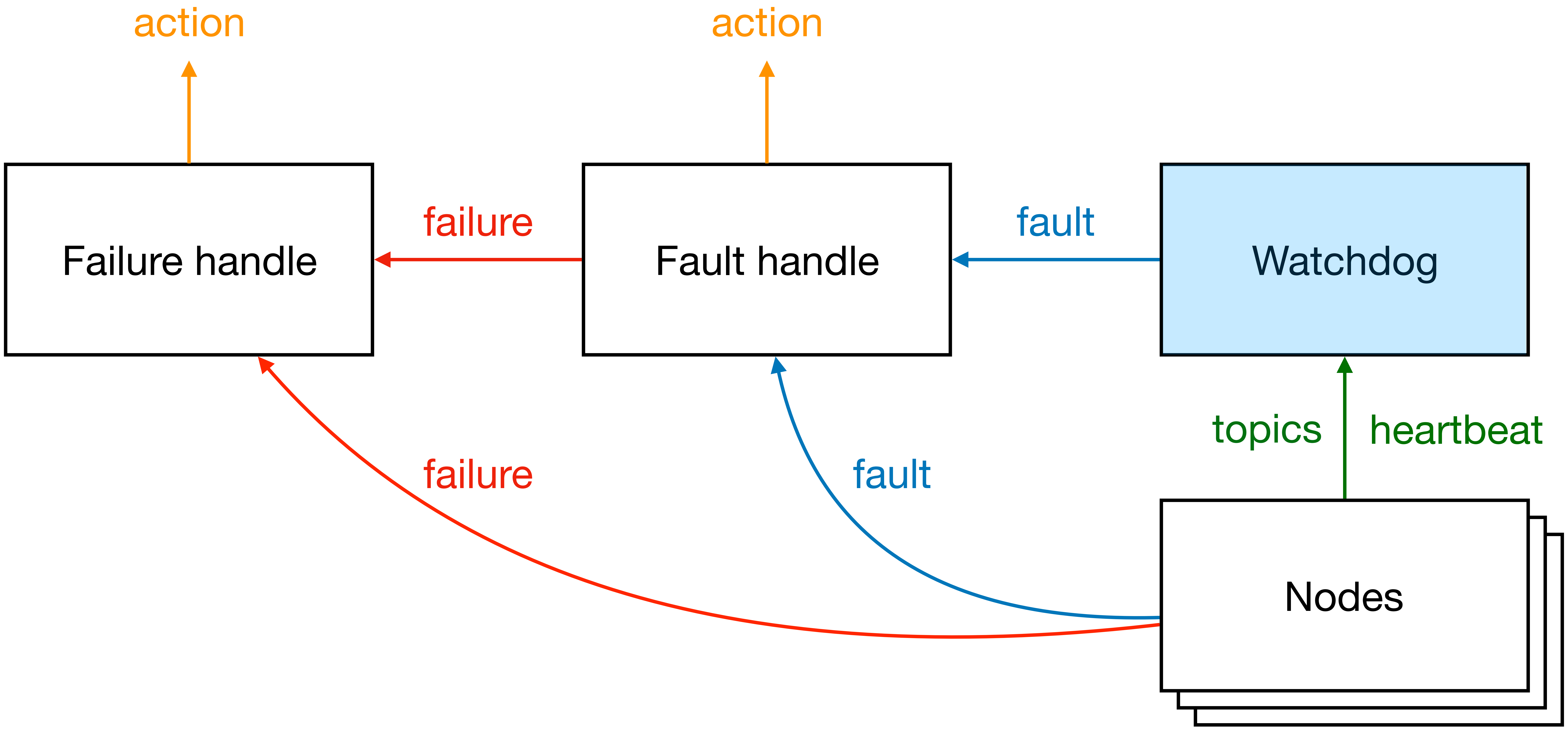
Fault Detection

Error: is a deviation from accuracy or correctness. Corrected with control.

Faults: an abnormal condition or defect at the component, equipment, or sub-system level which may lead to a failure.

Failures: Non-recoverable behaviour

Fault Detection



action
action
Failure handle
failure
Fault handle
fault
Watchdog
topics
heartbeat
failure
fault
Nodes