Advanced Robotics and Automated Systems (ARAS)
K. N. Toosi University of Technology
Tehran, Iran.

# Deep Learning Techniques

## for Object Detection and Tracking on ARAS Autonomous Car

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# Introduction to ARAS

# Introduction

- ARAS History
  - Established in 1997 for joint research collaboration between:
    - Faculty of Electrical and Computer Engineering
    - Faculty of Mechanical Engineering
  - Accomplished Projects in Industrial Robotics, Robotic Cells, Automated equipment and systems.
  - Research themes on Autonomous Robotics, Surgical Robotics, Parallel and Cable Robotics, and Dynamical System Analysis and Control

# Current Research Themes

1 **Autonomous Robotics**
SLAM, Navigation

2 **Surgical Robotics**
Eye-Surgery Training System

3 **Parallel and Cable Robotics**
Delta, Spherical, Constrained and Suspended CR

4 **Dynamical Systems Analysis and Control**
Robust and Nonlinear Control for Robotic Systems

# Autonomous Robots

Advanced Robotics and Automated Systems (ARAS)

# Autonomous Robots

- Research Topics:
  - Stereo based visual navigation of mobile robots
  - Robust RGB-D SLAM
  - Autonomous navigation of a quad-rotor with Mono-SLAM
  - Mobile robot motion planning under uncertainty
  - Loop closure detection by algorithmic information theory
  - Modeling of 3D objects by NURBS
  - Real-time 3D modeling of outdoor environments
  - Deep learning for autonomous cars

# Deep learning for autonomous cars


## Technical Steps Towards Autonomous Driving

# Classification of road scene images

➢ The road scene is classified pixel-wise by Seg-Net:

- Buildings
- Trees
- Sky
- Cars
- Sign-symbol
- Road
- Pedestrian
- Bicyclist
- …..

**Buildings**

# Classification of road scene images

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Trees

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**Sky**

# Classification of road scene images

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- …..

Cars

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Sign - symbol

# Classification of road scene images

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Road

# Classification of road scene images

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- Road
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- Bicyclist
- .....

Pedestrain

# Classification of road scene images

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  - Buildings
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  - Road
  - Pedestrian
  - Bicyclist
  - …..

**Bicyclist**

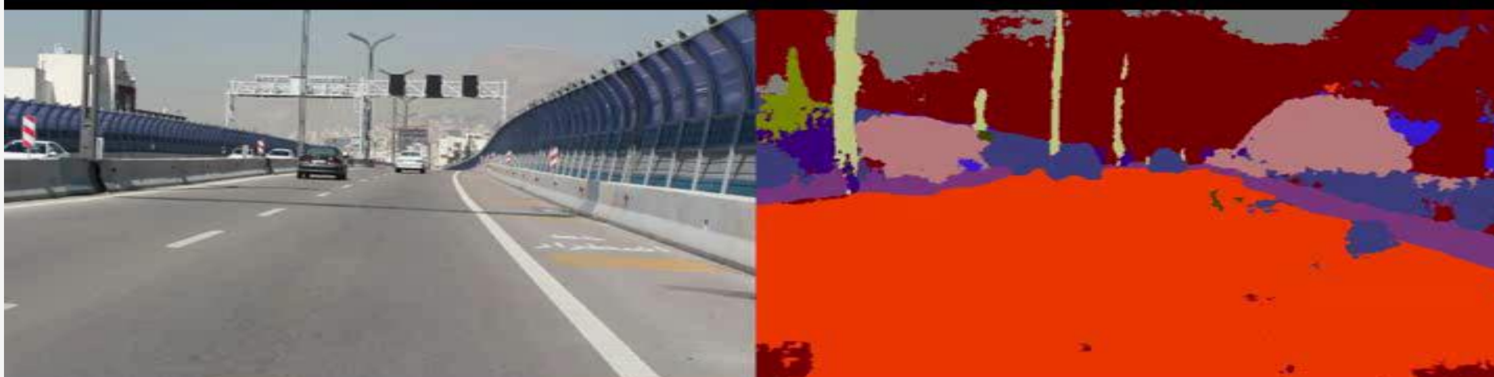
# Classification of road scene images

## ➢ Seg-Net @ CamVid

- The Seg-Net is trained on the CamVid Dataset.
- The CamVid Dataset consists of 367 training and 233 testing images of road scenes, taken around Cambridge, UK.
- The SegNet algorithm is tested on local street images captured in Iran.
- No additional training is performed.
- The segmentation results are presented without any post-processing.

# Classification of road scene images

Online deep learning implementation on Sard Highway, Tehran.



The segmentation results are presented without any post-processing.

# Classification of road scene images

## ➢ Implementation Results

- The Seg-Net algorithm is applicable in new scenes even without further training.
- The domestic car models are new to the network.
- Further training of the network on local road scene images improves the classification results.

# Deep learning for autonomous cars

## ➢ Object Detection

- The You-Look-Only-Once (YOLO Tiny v3) algorithm is employed for object detection.
- The algorithm is being trained for cars and video captures in the home town.
- The algorithm is implemented on a Jetson TX2 board.
- The object detection is performed in Real-time (17 FPS).
- The object detection results is suitable.
- Both cars and traffic lights are detected in the video.

# Object Tracking

# Object Detection

- Quick: A domestic car from SAIPA Co. is employed for object detection from camera images.

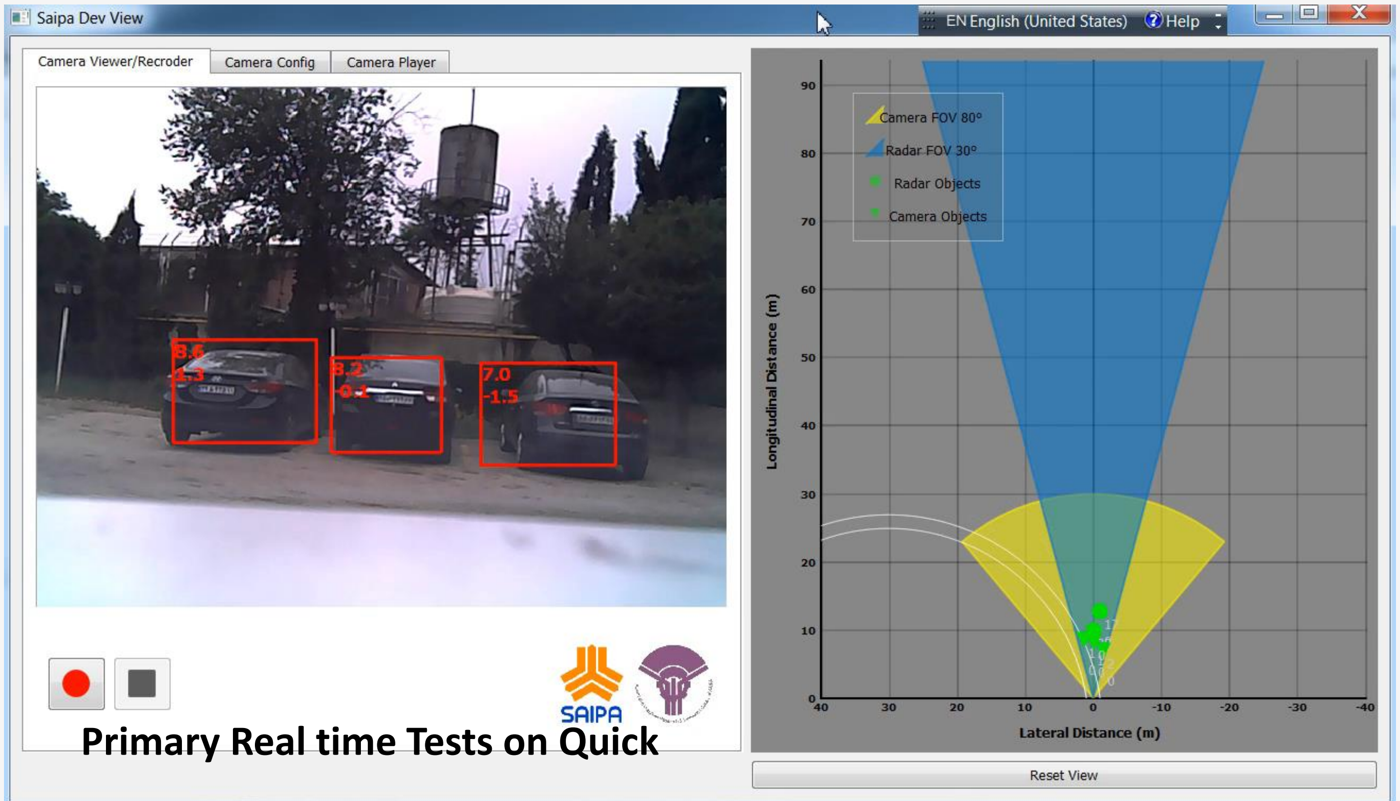
# Object Tracking

➢ Object tracking is performed continuously while new objects are added after detection.

**Real-time Object tracking**

**Object Detection** → **Tracking of new detected objects** → **Adding new objects to the tracking list**

# Object Tracking



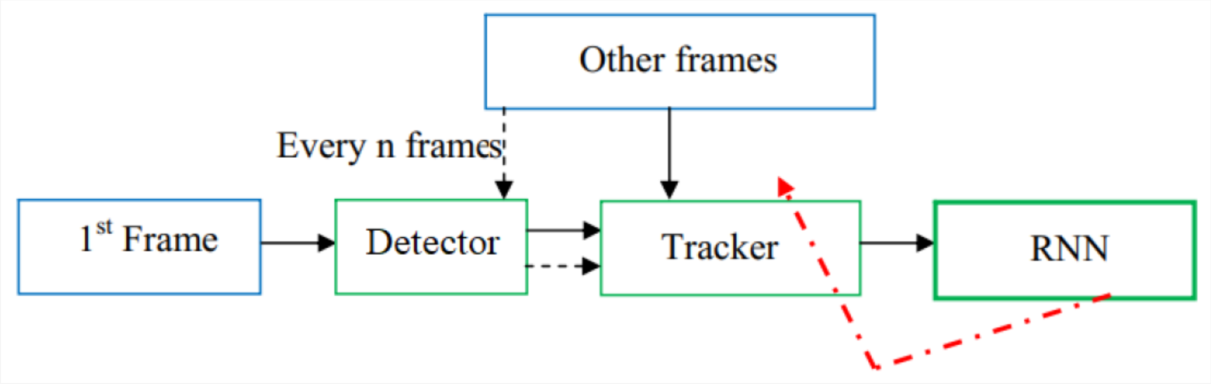

**Primary Real time Tests on Quick**

# Robust Object Tracking Based on RNNs

- Object tracking is prune to blurred images and occlusion.
- A method based on convolutional and recurrent neural networks is proposed to enhance the performance and robustness of object tracking.
- Real time implementation is provided and compared to some conventional object tracking methods.

# Robust Object Tracking Based on RNNs

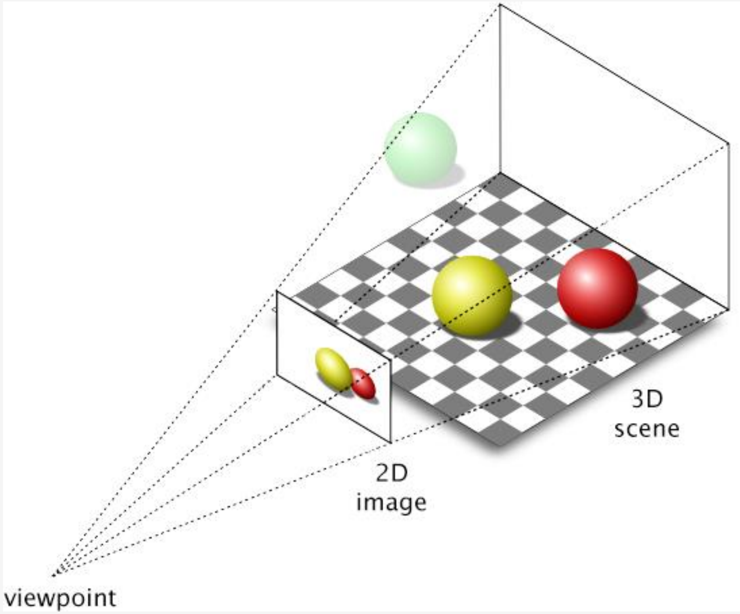
- Structure of the Proposed Tracker



# Robust Object Tracking Based on RNNs

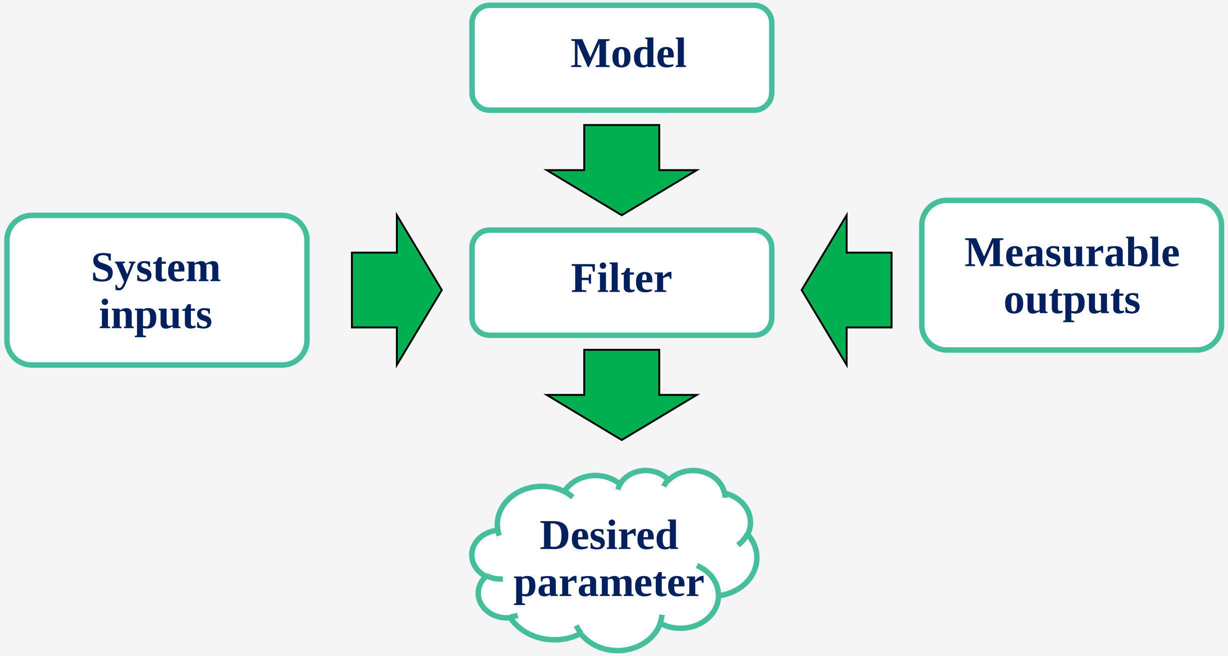
# Depth Estimation By SDRE Filter

- Depth estimation from camera images is still challenging.



# Depth Estimation By SDRE Filter

- Use Filters for Depth Estimation



# Depth Estimation By SDRE Filter

- SDRE filter
  - Nonlinear system

$$\dot{x}(t) = f(x,u) + \Delta f(x,u) + Gw_0$$
$$y(t) = h(x,u) + \Delta h(x,u) + D(t)v_0$$

SDC form:

$$\dot{x} = A(x)x + \Delta f(x) + B(x)u + \Delta B(x)u + Gw_0$$
$$y = C(x)x + \Delta h(x) + D(x)u + \Delta D(x)u + D_1 v$$

  - Filter Formulation

$$\dot{\hat{x}} = A(\hat{x})\hat{x} + B(\hat{x})u + K(\hat{x},t)[y - C(\hat{x})\hat{x} - D(\hat{x})u]$$
$$K(\hat{x}) = P(\hat{x})C(\hat{x})^T R^{-1}$$
$$\dot{P}(\hat{x}) = (A(\hat{x}) \text{-} K(\hat{x})C(\hat{x}))P(\hat{x}) + \ldots$$
$$P(\hat{x})(A(\hat{x}) - K(\hat{x})C(\hat{x}))^T + K(\hat{x})RK^T(\hat{x}) + GQG^T$$

# Depth Estimation By SDRE Filter

# Deep learning for autonomous cars


## Technical Steps Towards Autonomous Driving

# Contact Us:

# THANK YOU

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