NEURAL NET TRACKING CONTROL OF A MOBILE PLATFORM IN ROBOTIZED WIRELESS SENSOR NETWORKS

Sevil Ahmed, Nikola Shakev, Lilyana Milusheva, Andon Topalov

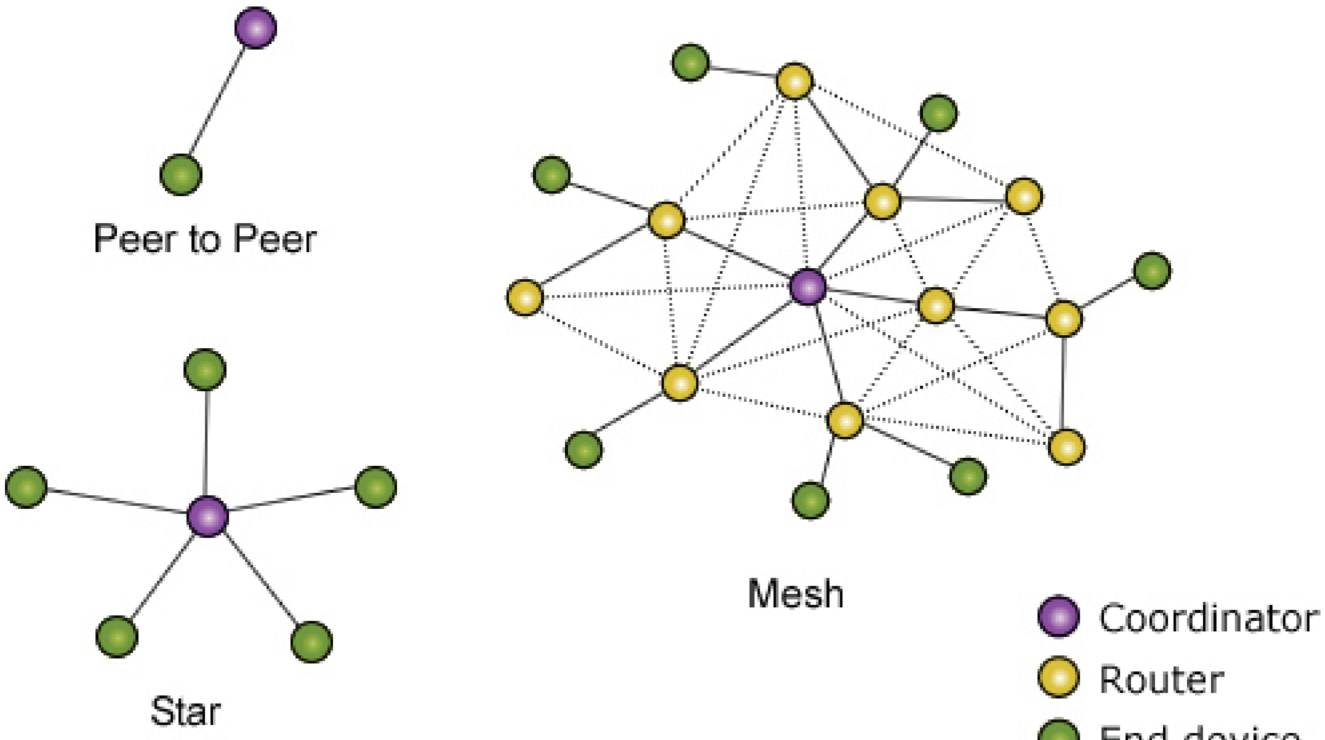
Department of Control Systems, Technical University–Sofia, Branch Plovdiv
25 Tsanko Djustabanov St., 4000 Plovdiv, BULGARIA

TECHNICAL UNIVERSITY SOFIA

Outline

- Introduction
- Prototyping the robotized sensor nodes
- The neural net trajectory tracking control approach
- The experiment
- Future work

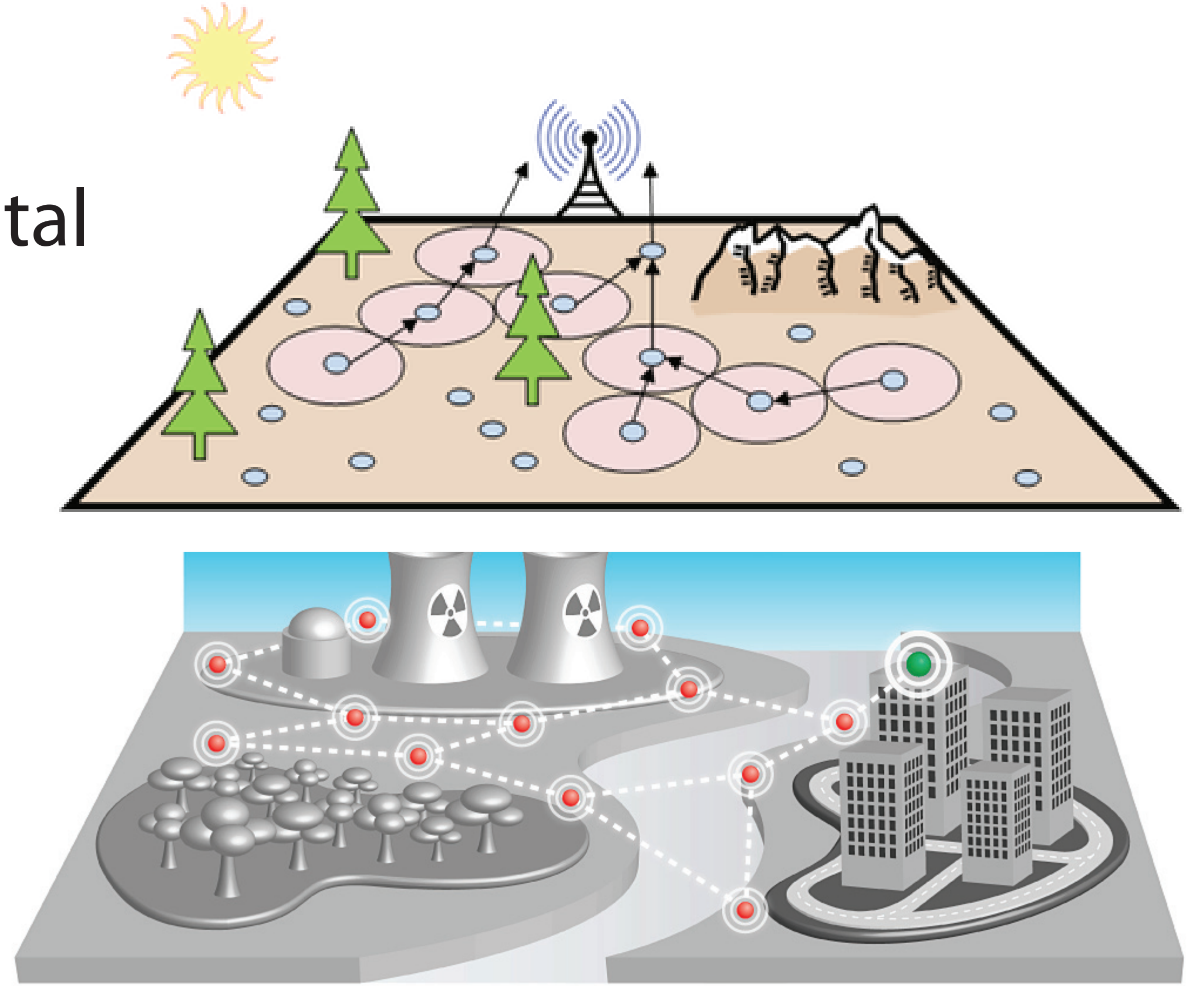
What is WSN?



- Distributed autonomous sensors - nodes
- Large number of nodes
- Collective data logging and transmission

Applications

- Monitoring environmental parameters
- Machine health monitoring
- Industrial process monitoring and control



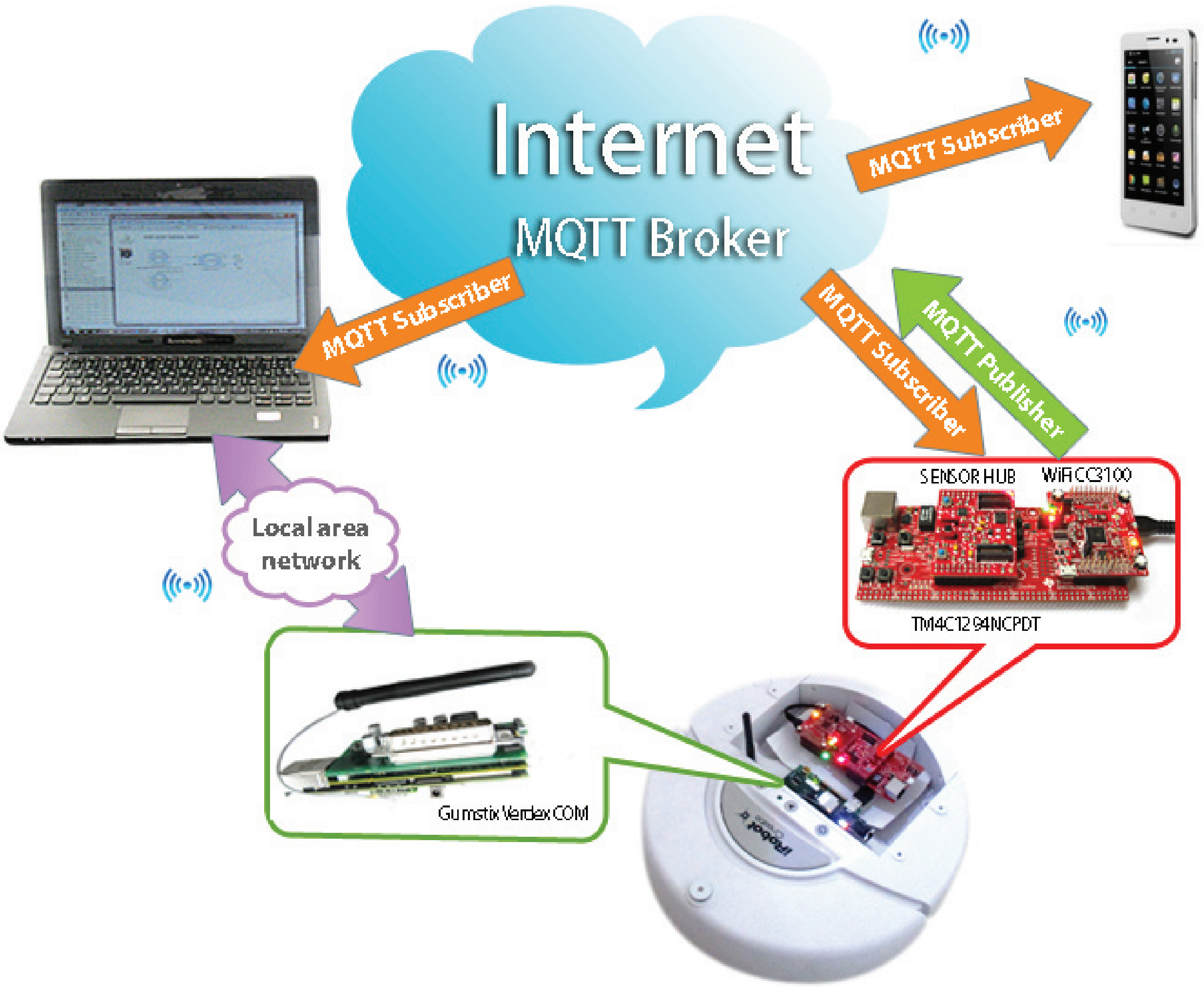
The trend - inclusion of mobile robots into the WSN structure!

- Provide flexibility with respect to the installation of the network sensors, thereby to allow active (not passive) information gathering

- If necessary, robots can perform desired or based on real-time observations interaction with the environment

Prototyping the robotized sensor nodes

Sensor node components:



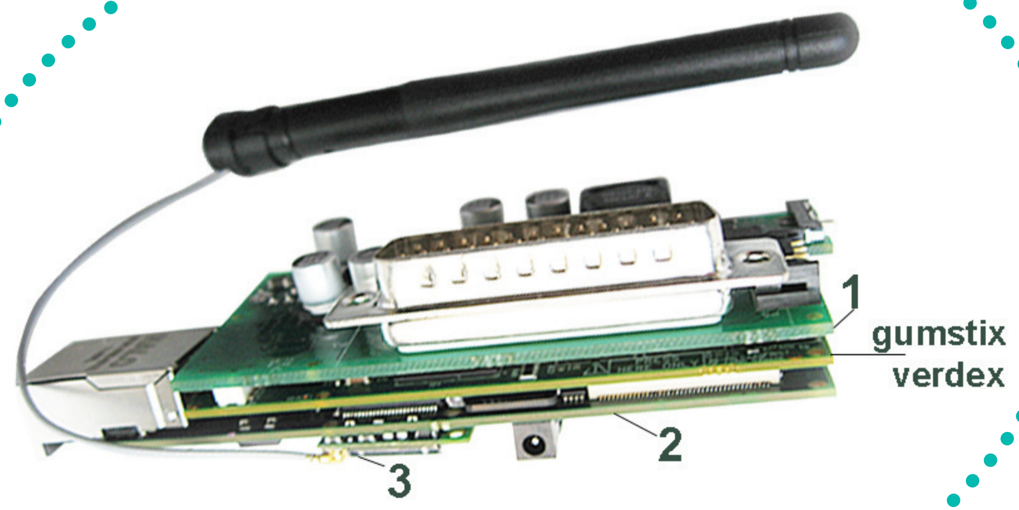
The communication:
two independent WiFi communication channels

- Local area network
- MQTT based communication

A. The Nonholonomic Mobile Robot iRobot Create

- Open interface
- Hardware expansion possibility
- Built-in sensors
- Differential-drive

B. The Embedded Microprocessor verdex pro™ XL6P COM



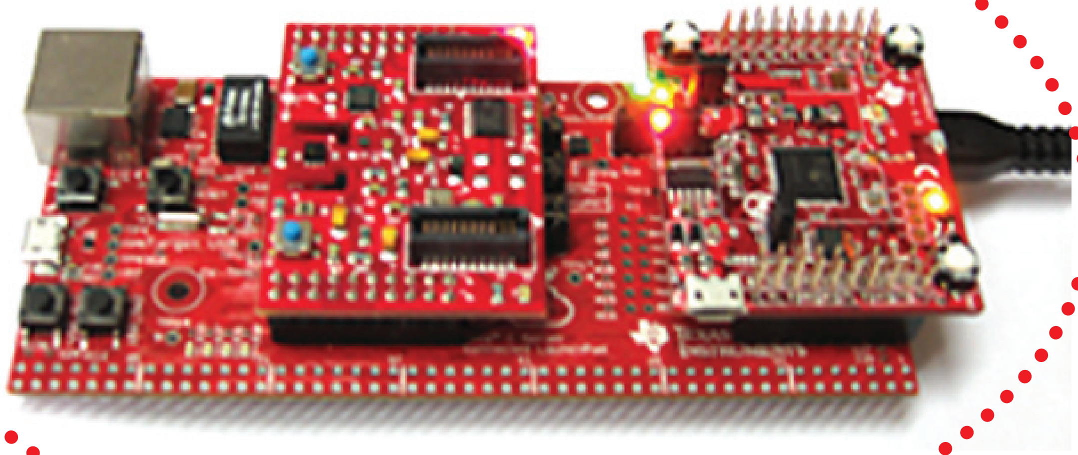
Hardware:

- Sticky interface
- Netpro-vx
- FCC WiFi module

Software:

- OE Linux - Angstrom distribution

C. The Sensor Pack



- Tiva™ C Series TM4C1294NCPDT LaunchPad
- WiFi CC3100 Booster Pack
- TI Sensor Hub

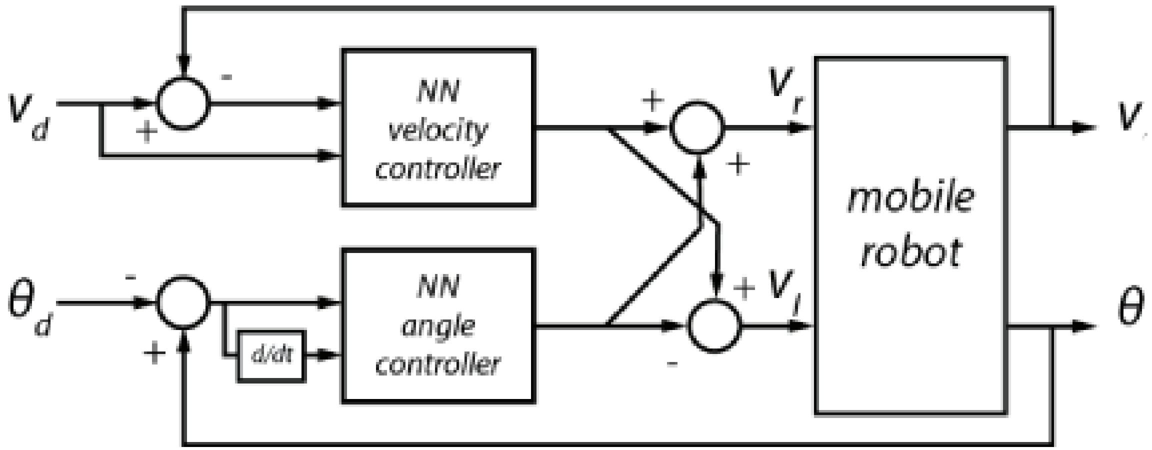
9-axis MEMS motion tracking; 3-axis gyro; 3-axis accelerometer; 3-axis compass; pressure sensor; humidity and ambient temperature sensor; ambient and infrared light sensor; non-contact infrared temperature sensor

Prototyping the robotized sensor nodes

The mobile sensor node

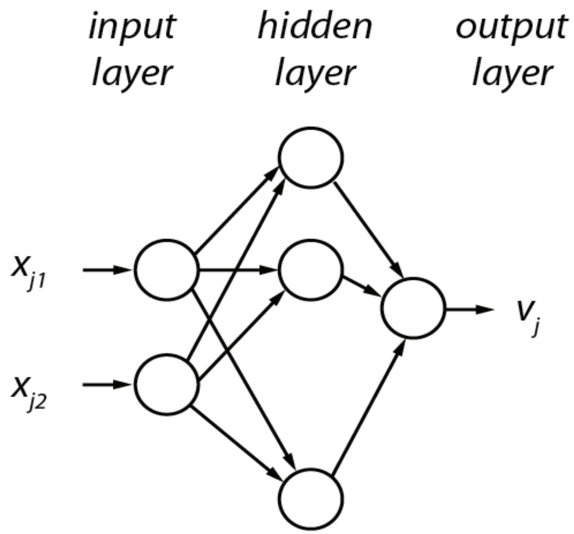
- Tiva™ C Series TM4C1294NCPDT LaunchPad
- WiFi CC3100 Booster Pack
- TI Sensor Hub
- Gumstix verdex stack

NN trajectory tracking control structure



$$v_r(t) = \frac{v_1(t) + v_2(t)}{2} \quad ; \quad v_l(t) = \frac{v_1(t) - v_2(t)}{2}$$

The neural net structure



$$x_{11}(t) = e_1(t) = v_d(t) - v(t) \qquad x_{21}(t) = e_2(t) = \theta_d(t) - \theta(t)$$

$$x_{12}(t) = v_d(t) \qquad x_{22}(t) = de_2(t)/dt$$

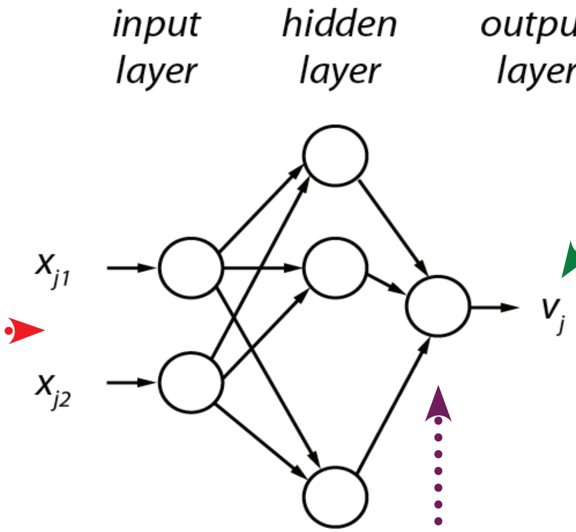
The neural net structure

$x_{11}(t) = e_1(t) = v_d(t) - v(t)$

$x_{12}(t) = v_d(t)$

$x_{21}(t) = e_2(t) = \theta_d(t) - \theta(t)$

$x_{22}(t) = de_2(t)/dt$



compound sine activation

$$\varphi_h(t) = \sin(h\pi\phi) = \sin\left(h\pi \frac{1}{1+e^{-a\sum_{i=1}^{2} x_{ij(t)}}}\right)$$

unipolar sigmoid function

$$\phi = \frac{1}{1+e^{-a\sum_{i=1}^{2} x_{ji}(t)}}, \quad j = 1,2$$

The neural net structure

$$v_j(t) = \sum_{h=1}^{g} w_{jh}(t)\varphi_h(t), \qquad j = 1,2$$

$$J(t) = \frac{1}{2}(e_j(t))^2, \quad j = 1,2.$$

$$\frac{dw_{jh}(t)}{dt} = \eta_j e_j(t)\varphi_h(t), \quad j = 1,2; \quad h = 1,2,\ldots,g$$

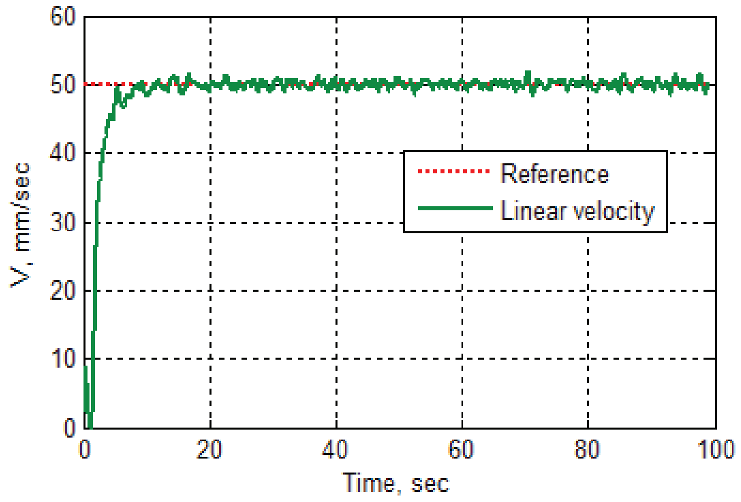
$$w_{jh}(t) = w_{jh}(0) + \int_0^t \eta_j e_j(t)\varphi_h(t)\,dt,$$

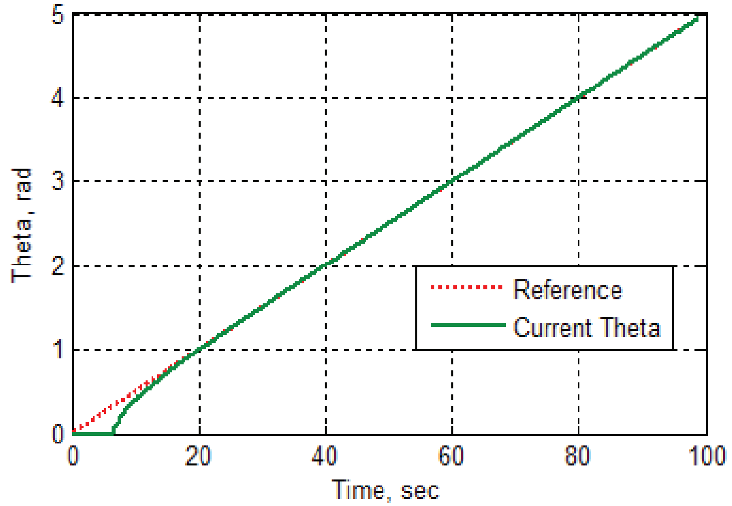
$$j = 1,2;\ h = 1,2,\ldots,g,$$

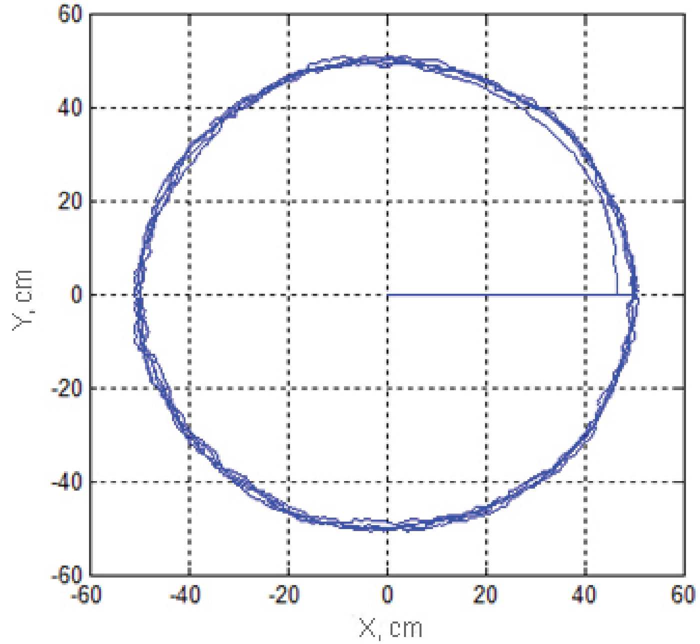
Scenario

- Detect any light source above the robot during the trajectory tracking performance
- Exact trajectory tracking
- Continuous sensor reading

A. Trajectory tracking performance







Controller	Learning rate	Neurons in the hidden layer	Initial weights
Velocity controller	300	5	10-3÷1
Orientation angle controller	0.75	7	10-3÷1

B. Sensor Reading and Data Broadcasting

- MQTT broker through iot.eclipse.org:1883

- MQTT broker through iot.eclipse.org:1883

Future work

Kuka youBot

UAVs

ACKNOWLEDGMENT

The authors gratefully acknowledge the financial support provided within the Ministry of Education and Science of Bulgaria Research Fund Project FNI I 02/6.

Thank you for your attention!