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NEURAL NETWORK CONTROL OF THE MOBILE ROBOTIC PLATFORM'S ADHESION FORCE

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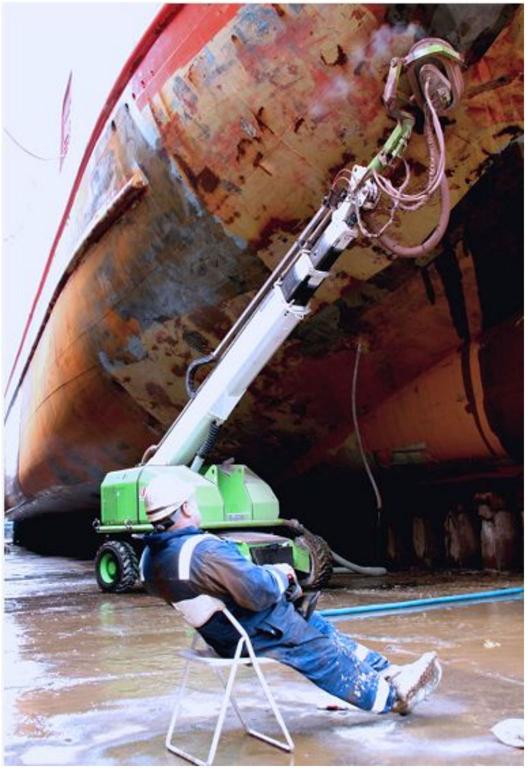
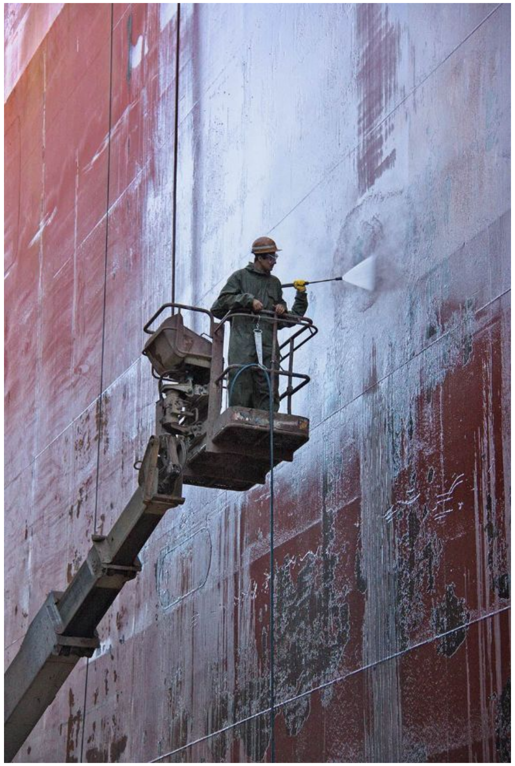
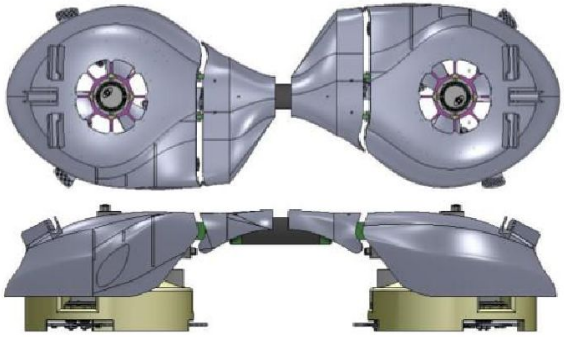
OUTLINE

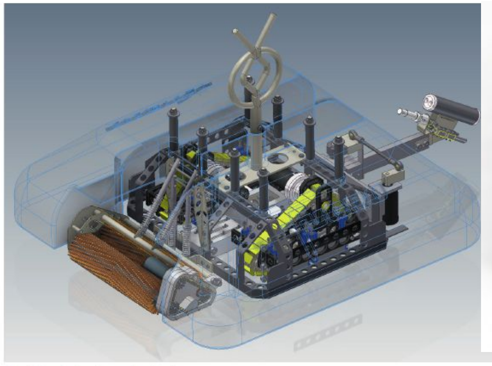
- Introduction
- The problem statement;
- Structure of the Control System for the UMRP's Adhesion Force;
- Development of the Neural Network Subsystem for Automatic Control of the UMRP Adhesion Force;
- Conclusions.

MOBILE ROBOTIC SYSTEMS AND COMPLEXES

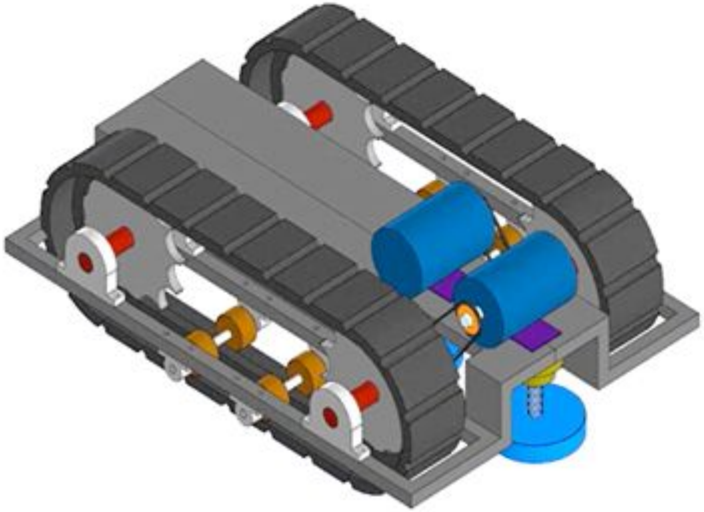


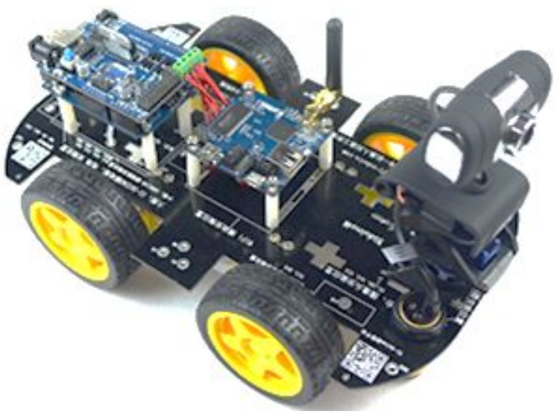






UNIVERSAL MOBILE ROBOTIC PLATFORMS

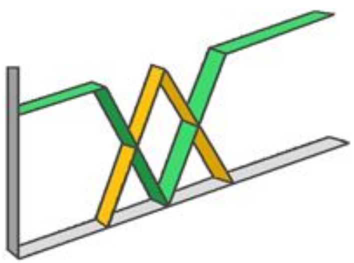




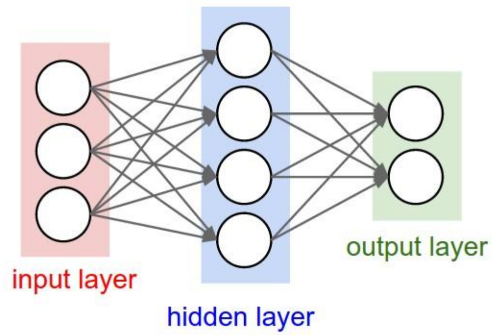
INTELLIGENT TECHNIQUES

Control devices implementation technologies

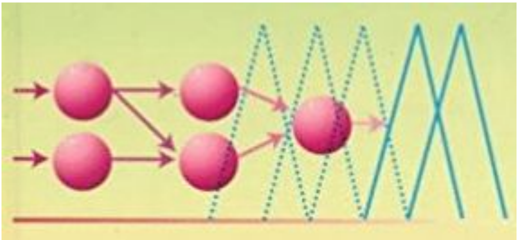
Fuzzy Systems



Artificial neural networks



Hybrid neuro-fuzzy systems

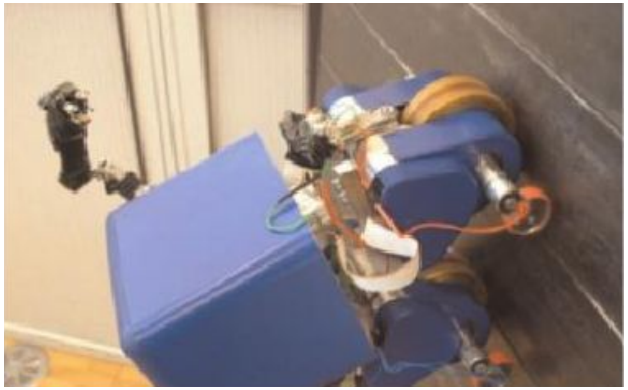


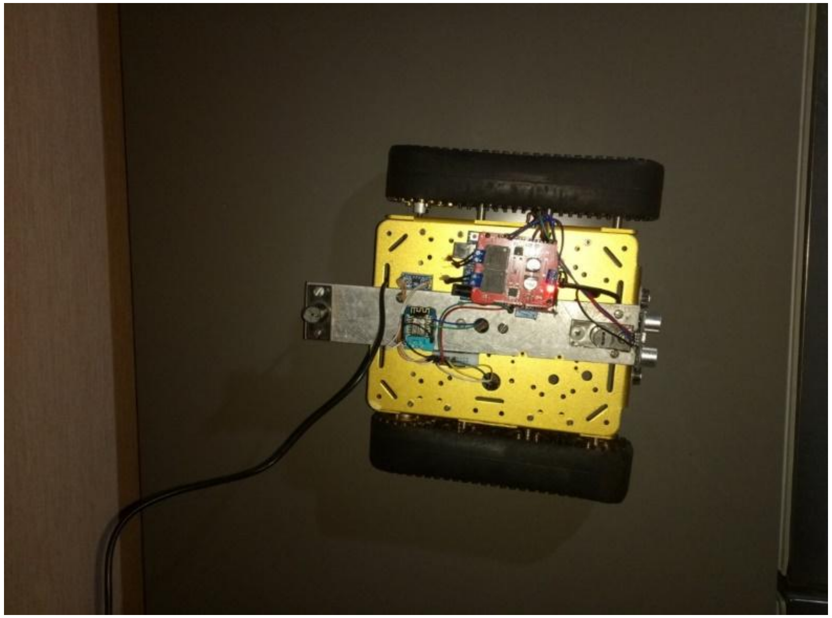
Designing methods technologies

Evolutionary algorithms

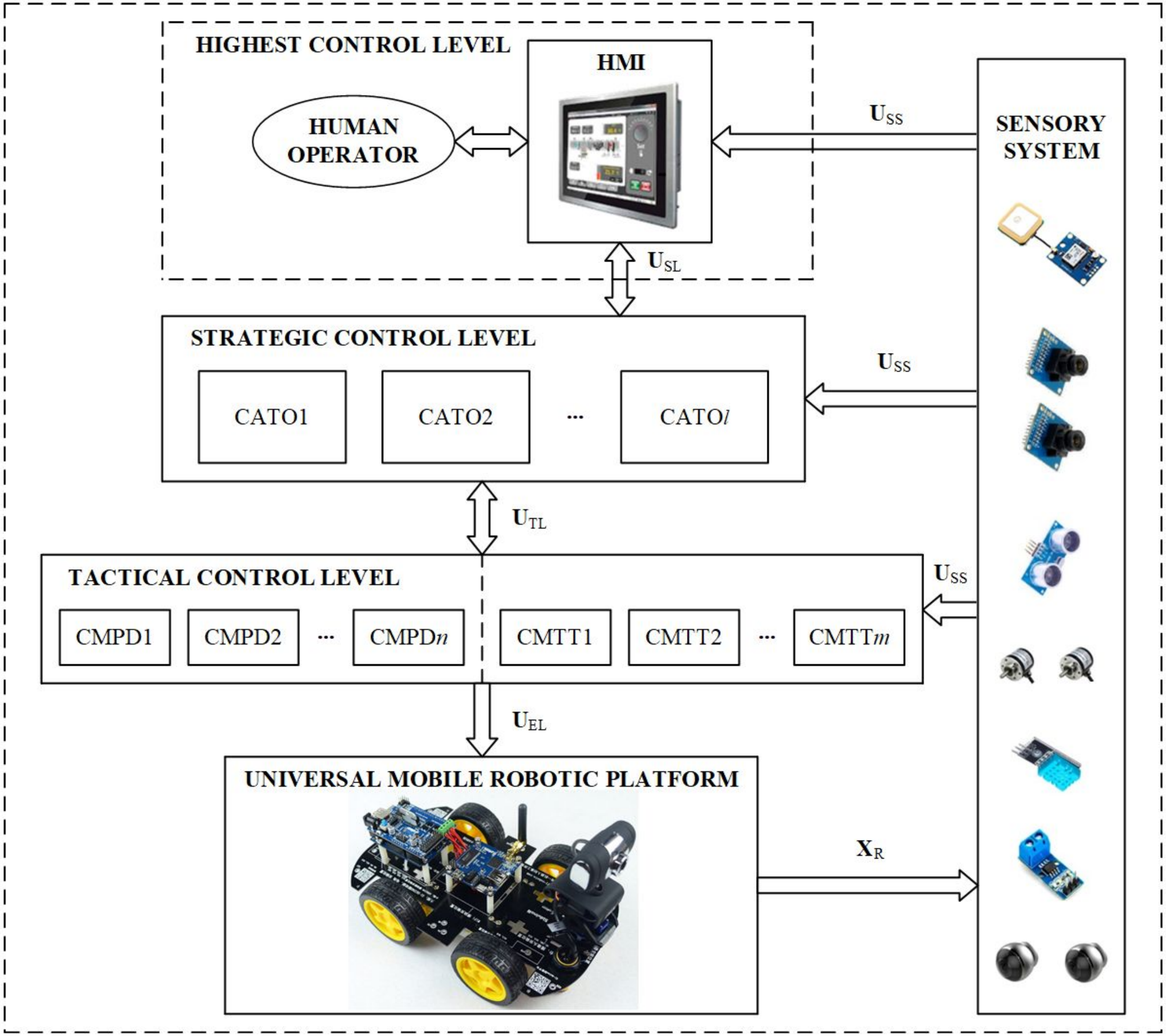
Multi-agent algorithms

PROBLEM OF ADHESION FORCE CONTROL

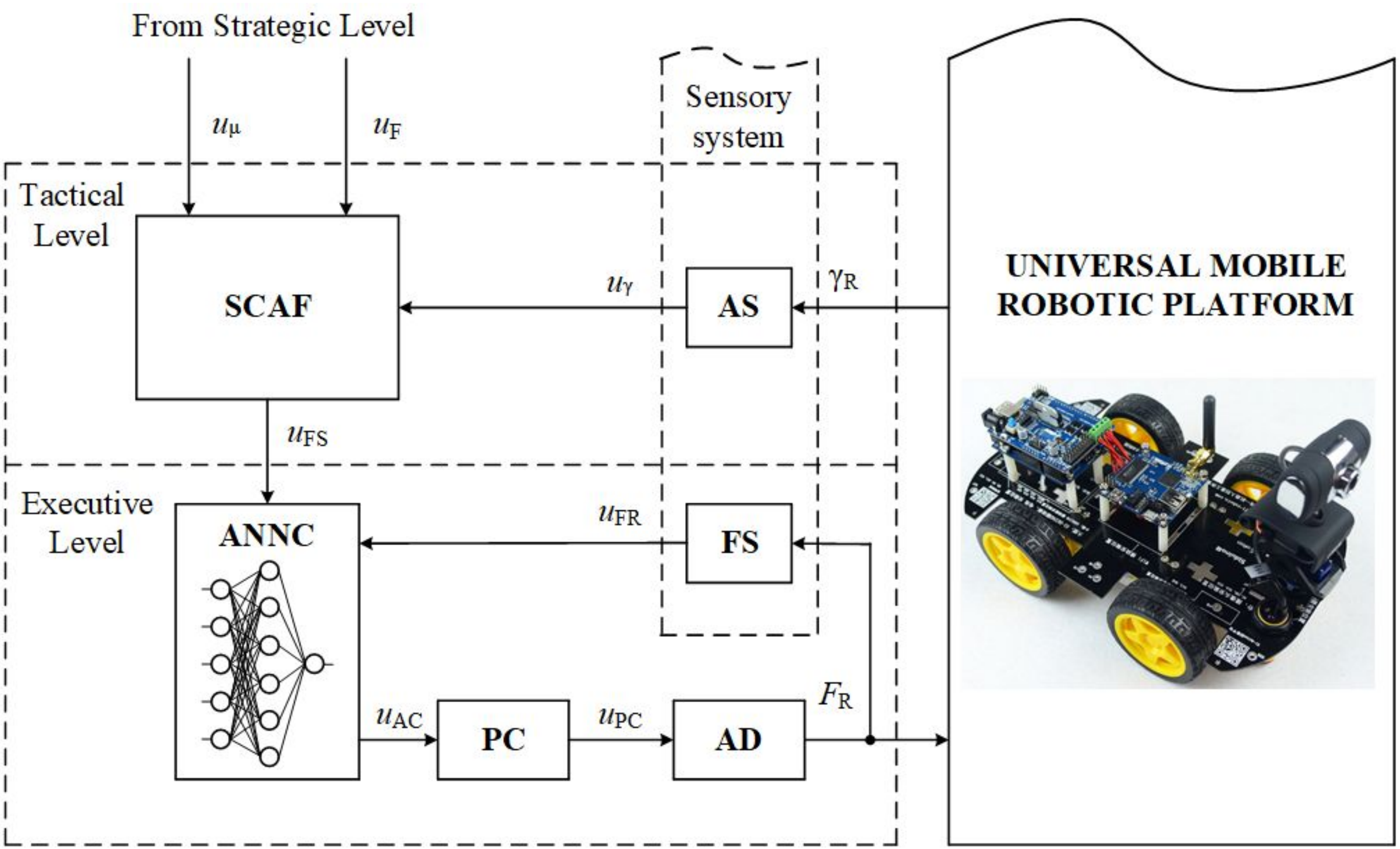




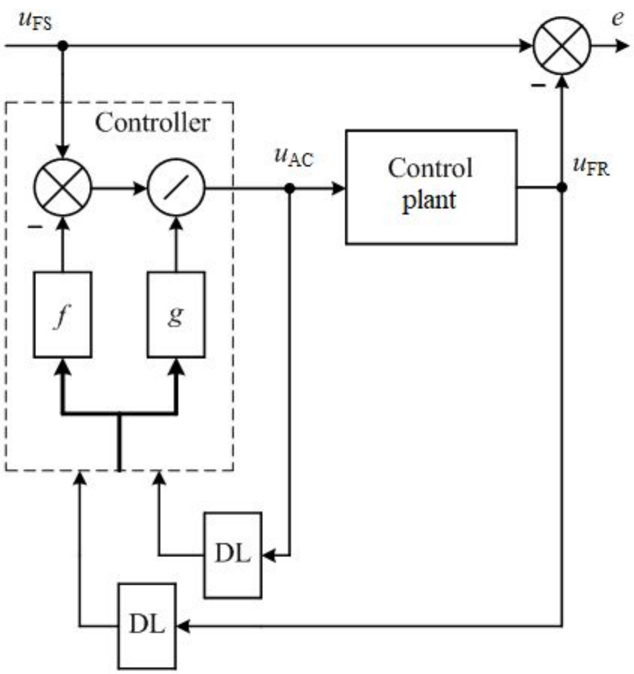
STRUCTURE OF THE GENERALIZED HIERARCHICAL CONTROL SYSTEM FOR THE UMRP

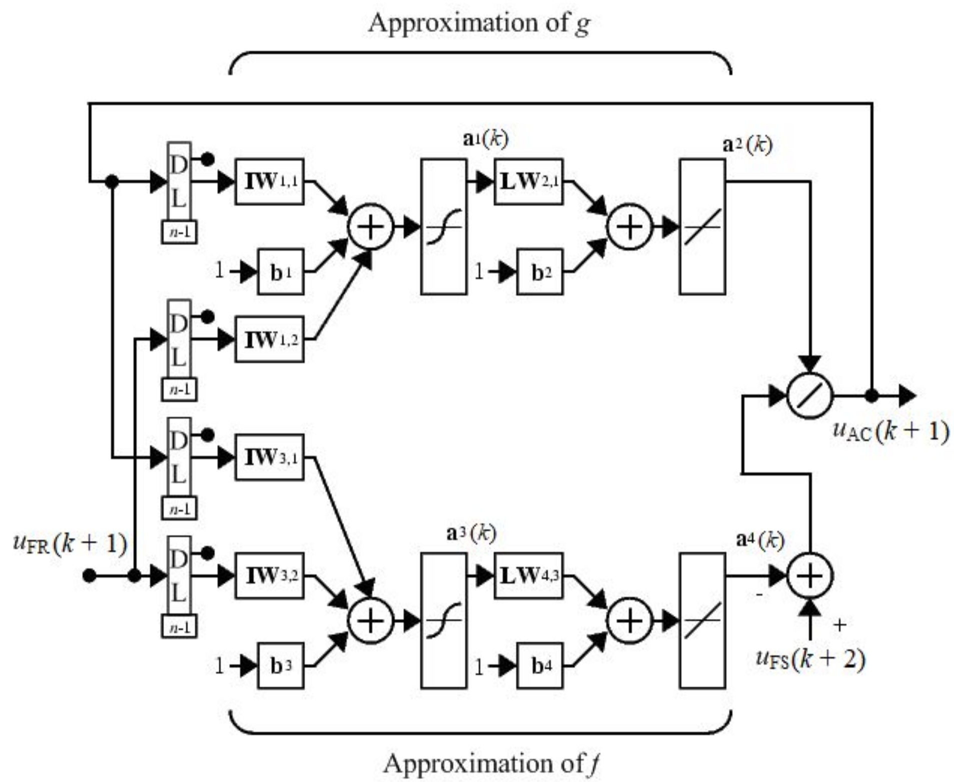


STRUCTURE OF THE TWO-LEVEL CONTROL SYSTEM FOR THE UMRP'S ADHESION FORCE



NEURAL NETWORK NARMA-L2 CONTROLLER



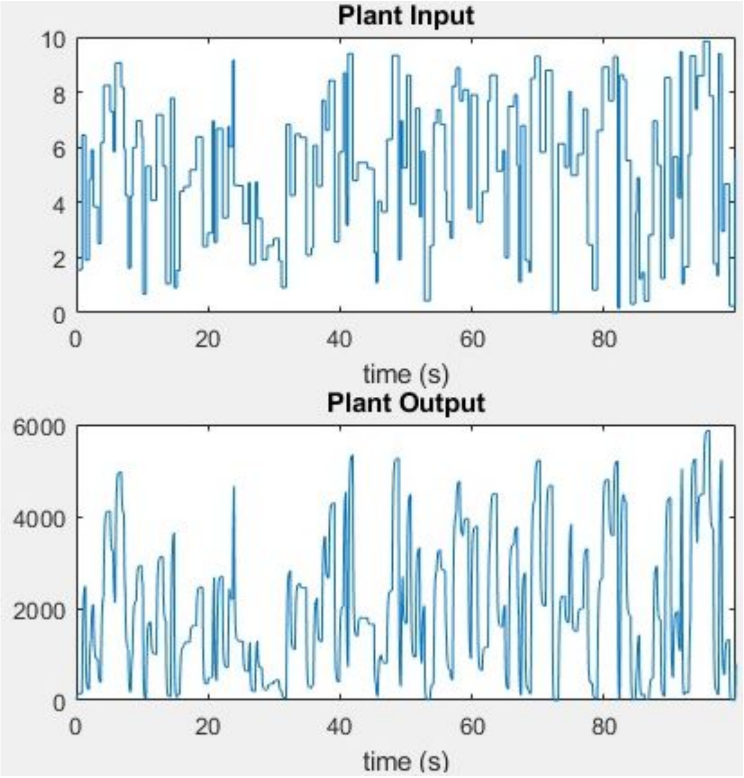


$$u_{AC}(k+1) = \frac{u_{FS}(k+d)}{g\left[u_{FR}(k), u_{FR}(k-1), \ldots, u_{FR}(k-n+1), u_{AC}(k-1), \ldots, u_{AC}(k-m+1)\right]} - \frac{f\left[u_{FR}(k), u_{FR}(k-1), \ldots, u_{FR}(k-n+1), u_{AC}(k-1), \ldots, u_{AC}(k-m+1)\right]}{g\left[u_{FR}(k), u_{FR}(k-1), \ldots, u_{FR}(k-n+1), u_{AC}(k-1), \ldots, u_{AC}(k-m+1)\right]},$$

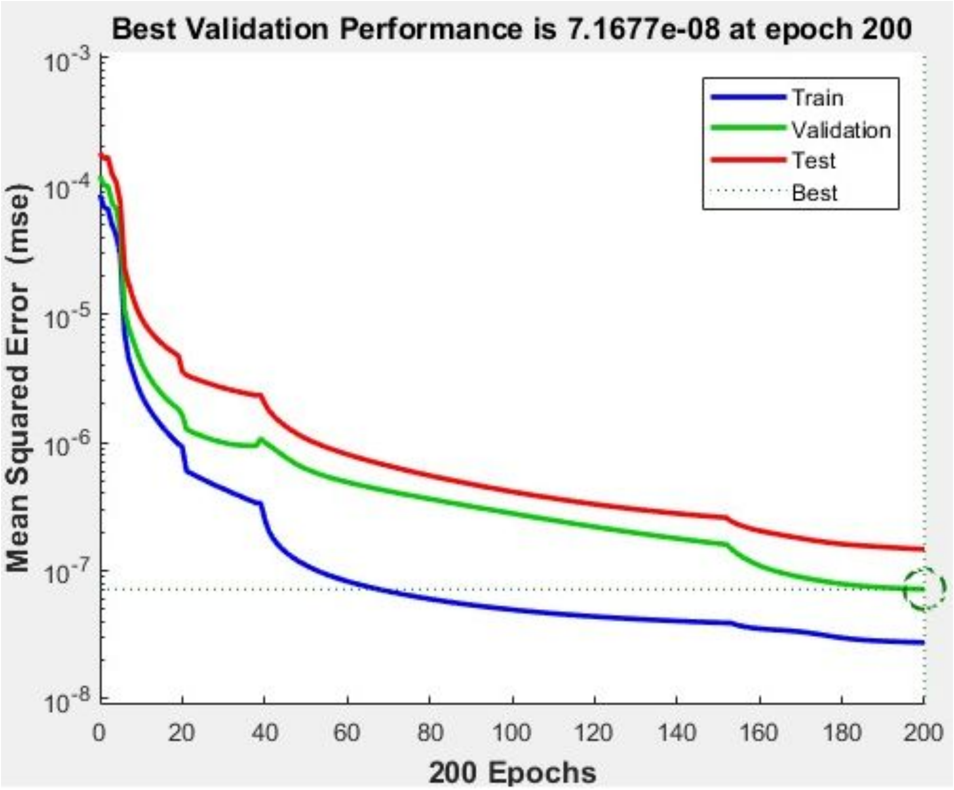
where d is the number of prediction cycles; $g(\cdot)$ and $f(\cdot)$ are the nonlinear operators. The equation is used when $d \geq 2$.

DEVELOPMENT OF THE NARMA-L2 CONTROLLER FOR THE ADHESION FORCE CONTROL SYSTEM

Identification Process of the Control Plant

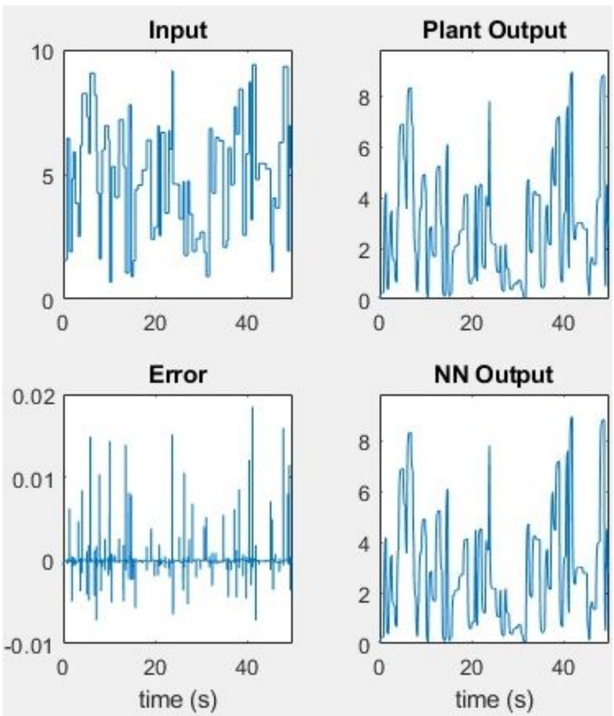


Training Process of the Neural Network Controller

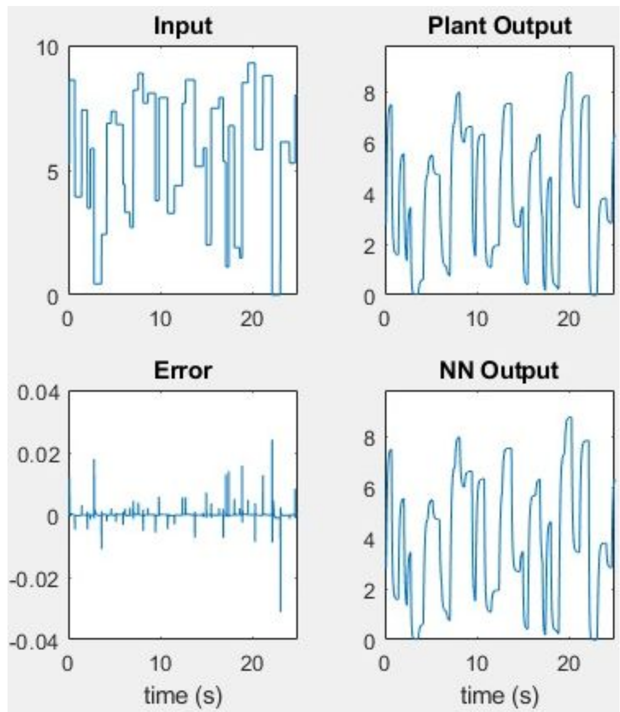


DEVELOPMENT OF THE NARMA-L2 CONTROLLER FOR THE ADHESION FORCE CONTROL SYSTEM

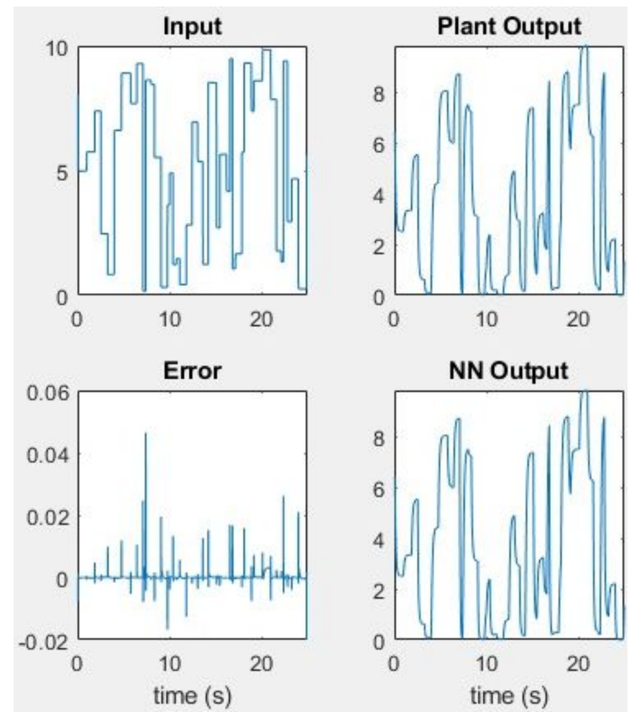
Training results



Validation results

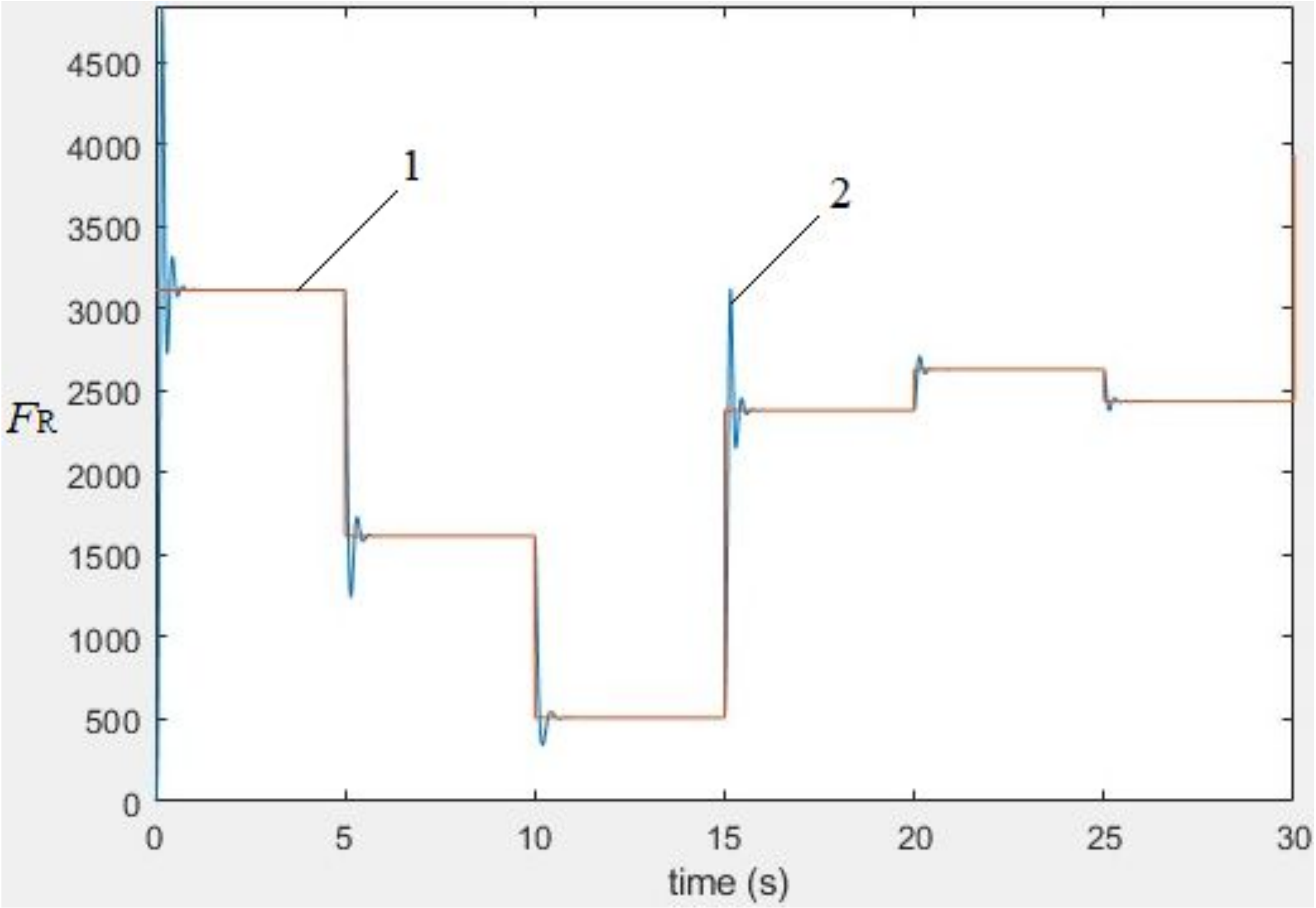


Testing results



DEVELOPMENT OF THE NARMA-L2 CONTROLLER FOR THE ADHESION FORCE CONTROL SYSTEM

Transients of control of the adhesion force value in case of an accidental change in the set point



1 - the given adhesion force value, which comes from the tactical level subsystem;

2 - the real value of the adhesion force, which is provided by the neural network subsystem of the executive level.

DEVELOPMENT OF THE NARMA-L2 CONTROLLER FOR THE ADHESION FORCE CONTROL SYSTEM

Quality indicators of transients of the adhesion force automatic control system in case of an accidental change in the set point

Step number	Set value, N	Step time, s	Control time, s	Overshoot, %
1	3140	0	0.625	59.12
2	1620	5	0.536	25.91
3	510	10	0.514	16.89
4	2410	15	0.612	39.47
5	2680	20	0.352	35.82
6	2460	25	0.265	32.14

CONCLUSIONS

- The proposed system for adhesion automatic control in the universal mobile robotic platform adopts a two-level structure, consisting of tactical and executive levels of automatic control.

- The executive-level subsystem is developed on the basis of the neural network and allows implementing proper stabilization and automatic control of the UMRP adhesion force. In particular, the NARMA-L2 neural network controller is designed and trained on the previously obtained training data that gives the opportunity to provide effective automatic control of the adhesion force value at different values of input and disturbing actions.

- The obtained simulation results in the form of transients of the adhesion force automatic control during the random changes in the set values show that the developed control subsystem based on the trained NARMA-L2 neural network controller has sufficiently high quality indicators of control. Namely, the proposed executive-level subsystem provides a sufficiently high accuracy and speed of the adhesion force automatic control (the maximum overshoot and the maximum control time are 59.12% and 0.625 seconds, respectively, at the zero value of the static error).

THANK YOU FOR YOUR ATTENTION!