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# Perceptual Anthropomorphic Walking Robot Platform for Navigation in Unstructured and Undifferentiated Environments

**Luige Vladareanu, Mihai Rădulescu, Marius Pandelea, Hongbo Wang, Florentin Smarandache, Yongfei Feng, Ionel-Alexandru Gal, Alexandra C. Ciocîrlan**

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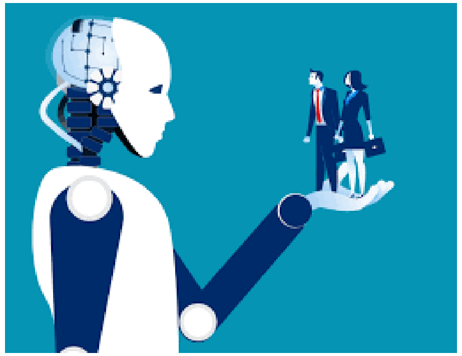


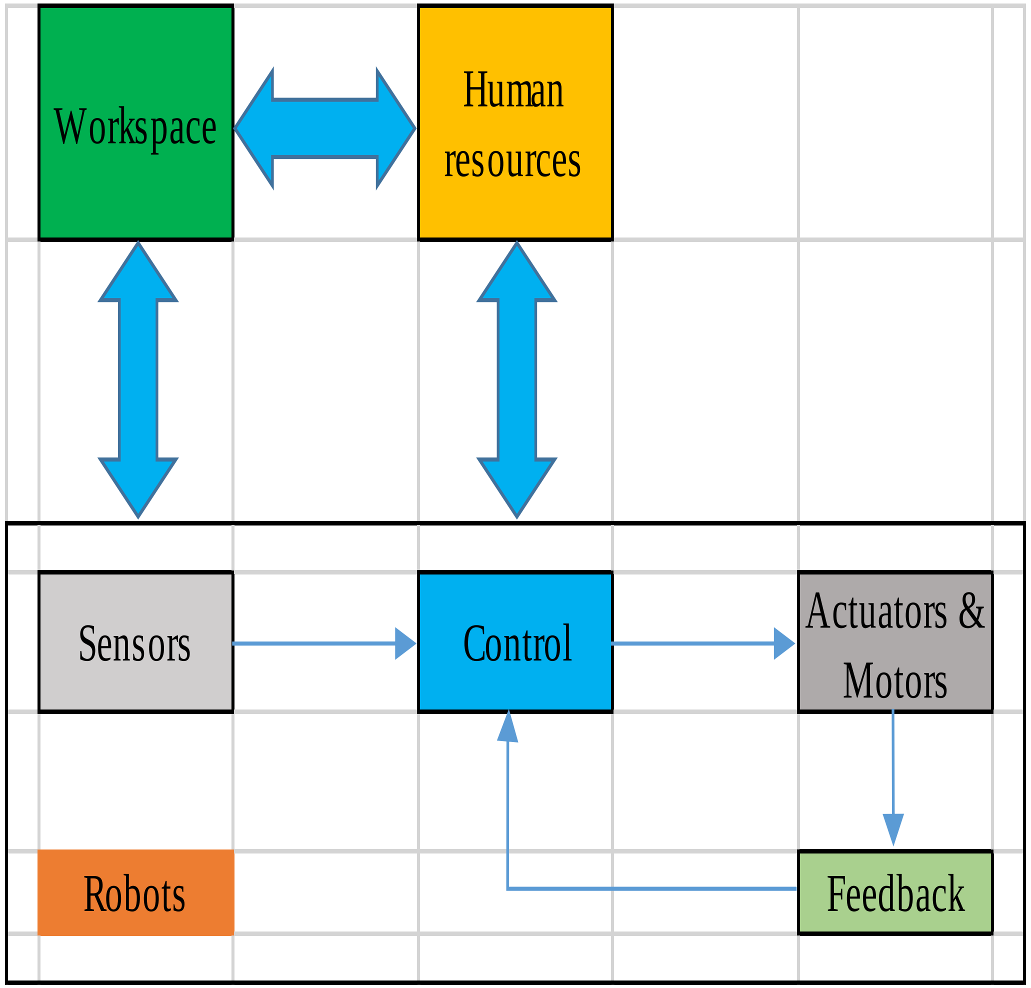
# INTRODUCTION

**<u>Influencing factors of the stability control and walking positions of the AWR:</u>**

- the number of degrees of freedom of the articulated mechanical structure and the type of joints,
- parts materials,
- the length and mass of the robots links,
- friction from the joints and friction with the supporting surface,
- inertia of dynamic elements,
- walking speed and acceleration,

**Influencing factors of the stability control and walking positions of the AWR:**

- the number, type and positioning of sensors,
- the number and type of engines,
- control strategies, methods and algorithms,
- delays due to communication,
- human experience,
- the conditions of the ambient working space.



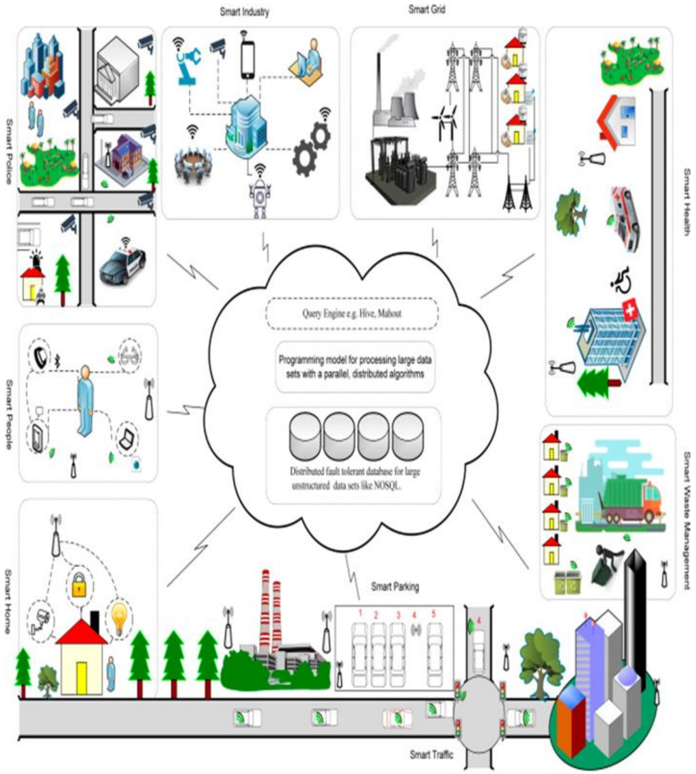

- AWR modelling for stability control is a necessity defined by degrees of freedom, actuators, dynamic factors of the environment, and quality and quantity of information

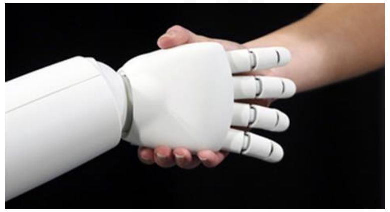
- the real-time control system of the AWR is based on the virtual projection method implemented on the VIPRO platform

- the new intelligent control interfaces used Ishikawa diagram and Pareto principle

- Ishikawa intelligent interface was developed for the identification and graphic representation of the categories of causes and the factors that cause the AWR to become unstable

- Pareto intelligent interface using predictive observation for reducing the number of causes, and potential instability factors in the control process

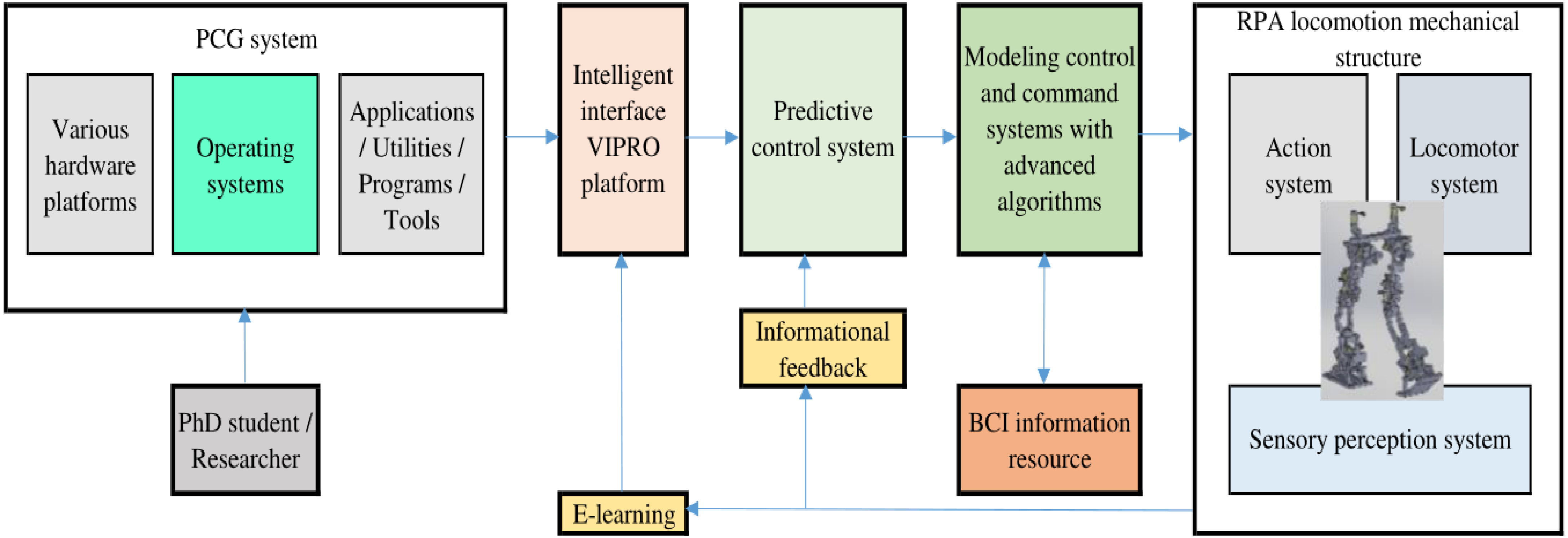




# VIPRO PLATFORM FOR CONTROL OF ANTHROPOMORPHIC WALKING ROBOTS

- The Vlădăreanu-Munteanu virtual projection method (V&M method) was practically validated with the help of the experimental model of the **VIPRO** platform which allowed the correct robot simulation
- The method ensures the possibility of interaction with cloud or Big Data technologies through remote communications and/or for the simulation of other parameters
- The VIPRO platform, is a portable robotic platform that ensures the optimization of performance related to the stability and movement of robots on uneven terrain characterized by a real or virtual environment

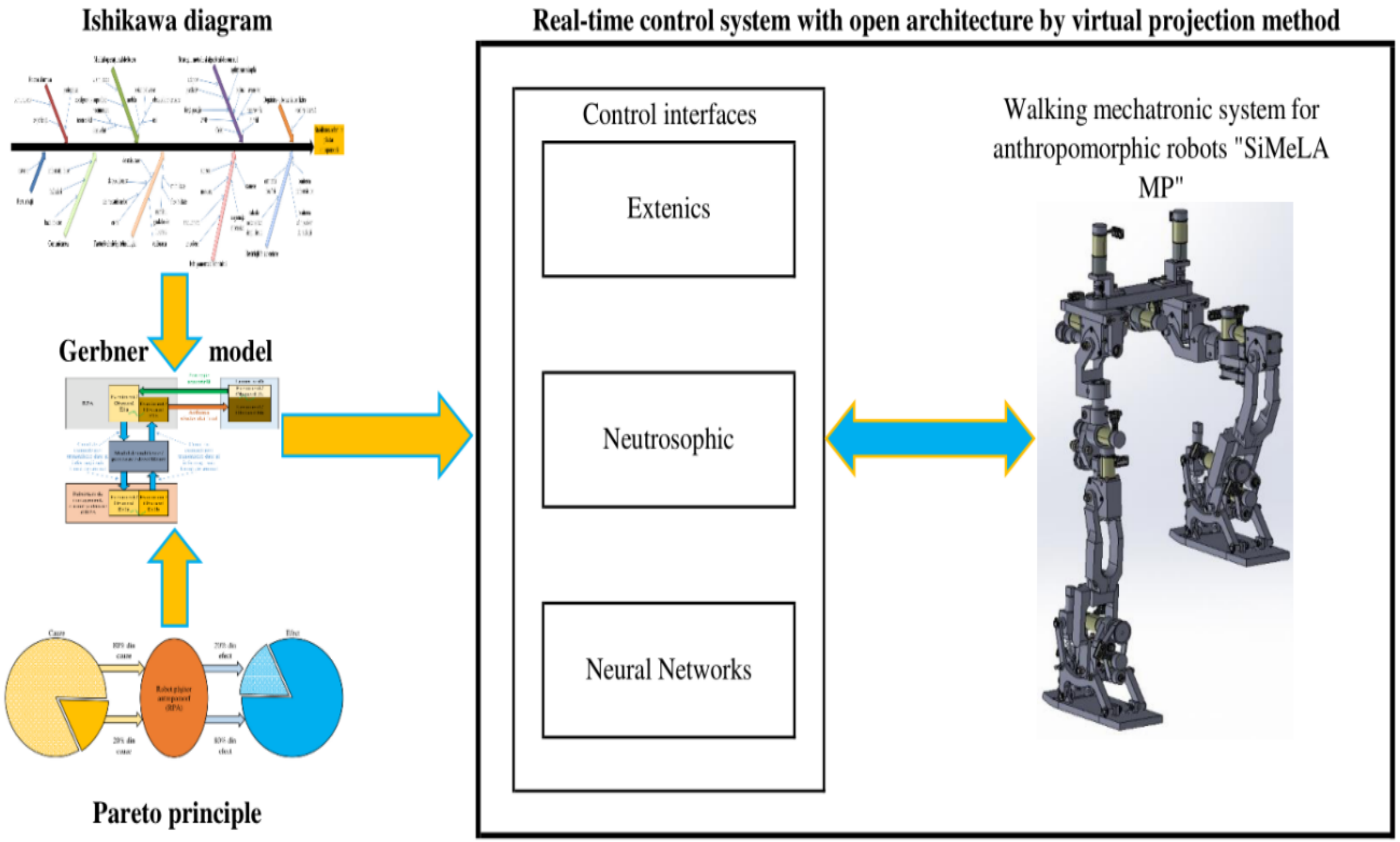
# VIPRO PLATFORM FOR CONTROL OF ANTHROPOMORPHIC WALKING ROBOTS




The VIPRO platform used in the AWR virtual control simulation process

- The control is based on sensors and intelligent algorithms that, by adjusting the values of the characteristic parameters, restore the state and posture of the mechatronic system deviated from the desired operation.

# VIPRO PLATFORM FOR CONTROL OF ANTHROPOMORPHIC WALKING ROBOTS




The intelligent interfaces for stability control integrated **VIPRO CS** architecture

- The AWR stability control is based on perception, processing of series of values of measured parameters, environmental conditions, communication and reaction of mechatronic systems.

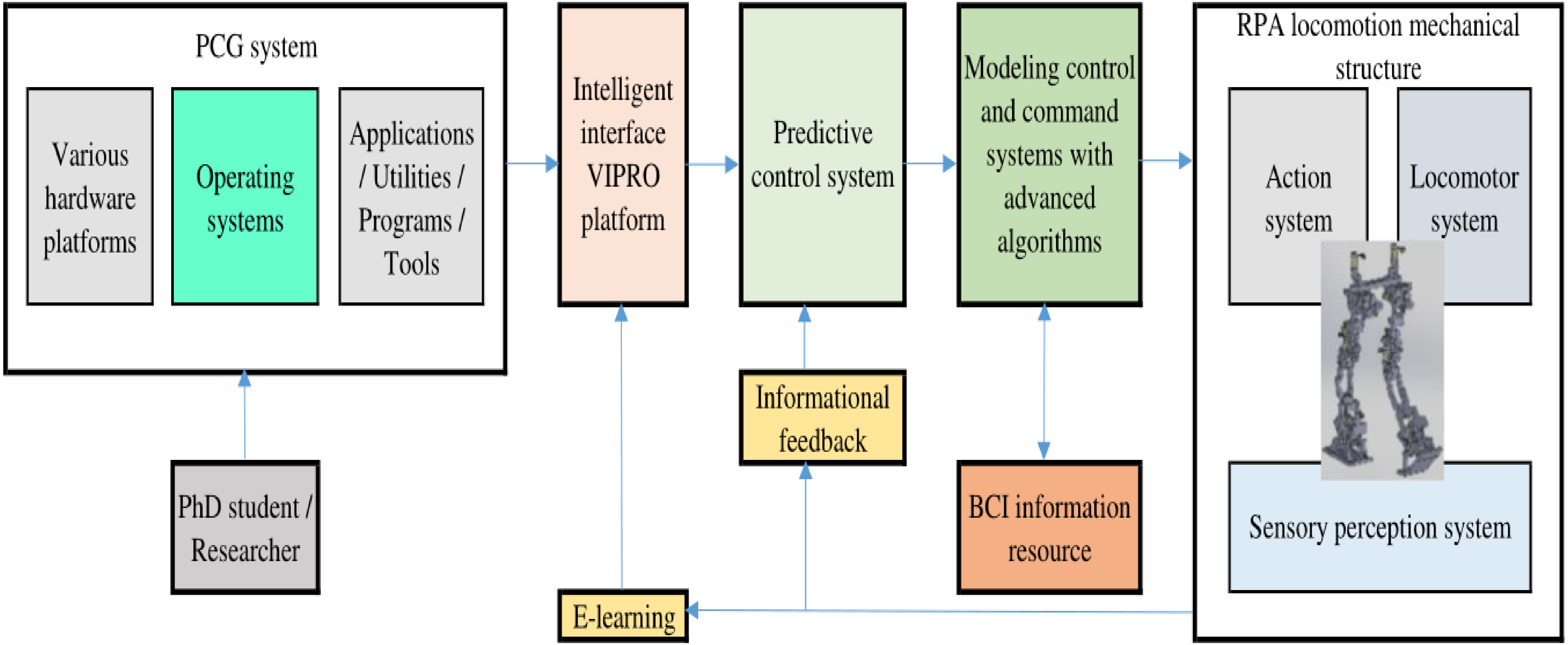
## VIPRO PLATFORM FOR CONTROL OF ANTHROPOMORPHIC WALKING ROBOTS

- The stability control of the SiMeLA MP robot starts with the V&M method and the hybrid force-position control method following the evolution of the ZMP and CoM points

- The novelty element is the fact that at the level of the hip, knee and ankle joints fine neutrosophic control stages are introduced in the sagittal and frontal plane to bring extra safety when the robot steps in an unknown environment with bumps and obstacles

- The control is carried out hierarchically, distributed and adaptively at the level of joint and mechanical segment of locomotion limbs

- The main elements of this strategy are the Ishikawa diagram, the Pareto principle, the Gerbner model adapted to the VIPRO platform and the SiMeLA MP robot




The VIPRO platform used in the AWR virtual control simulation process

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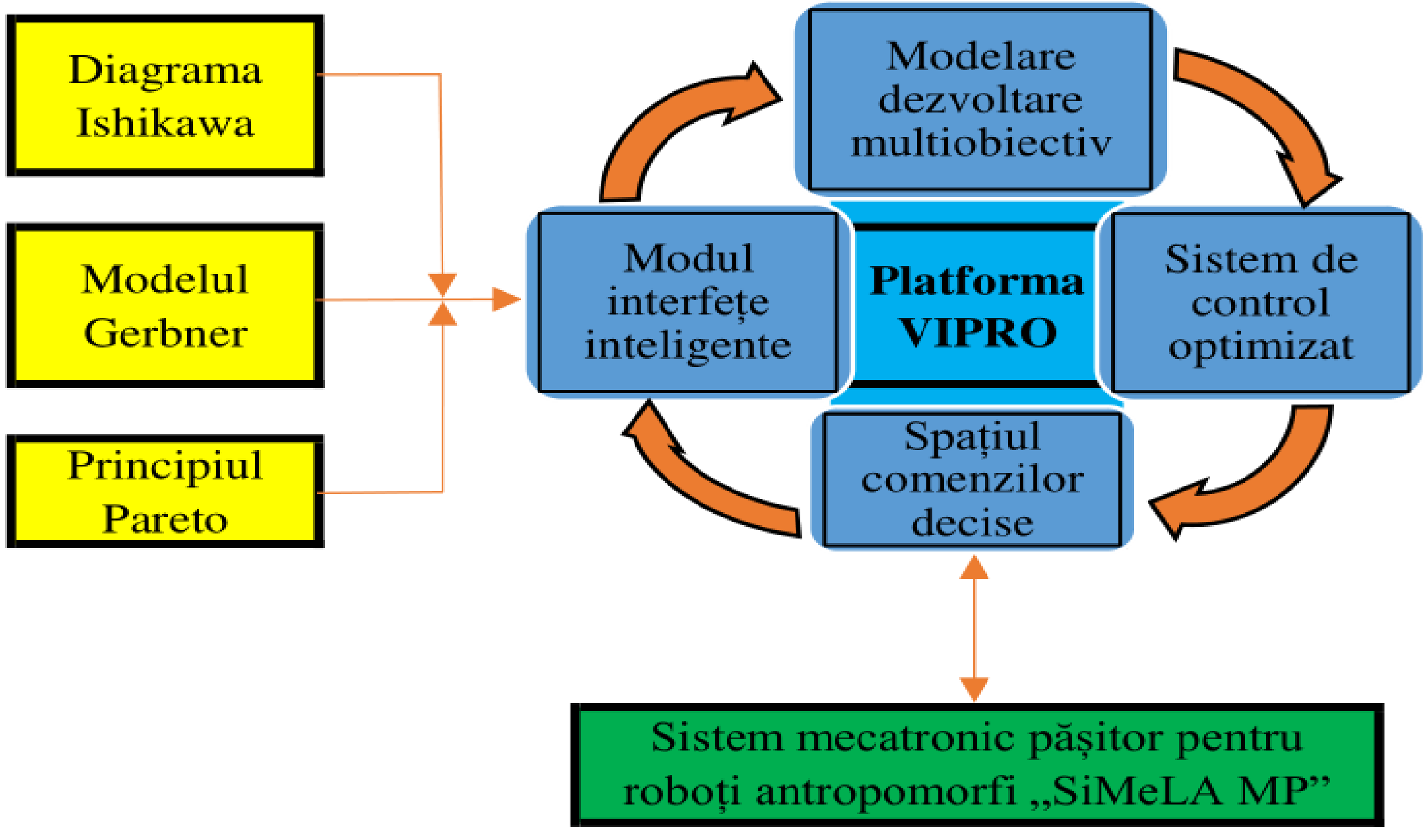
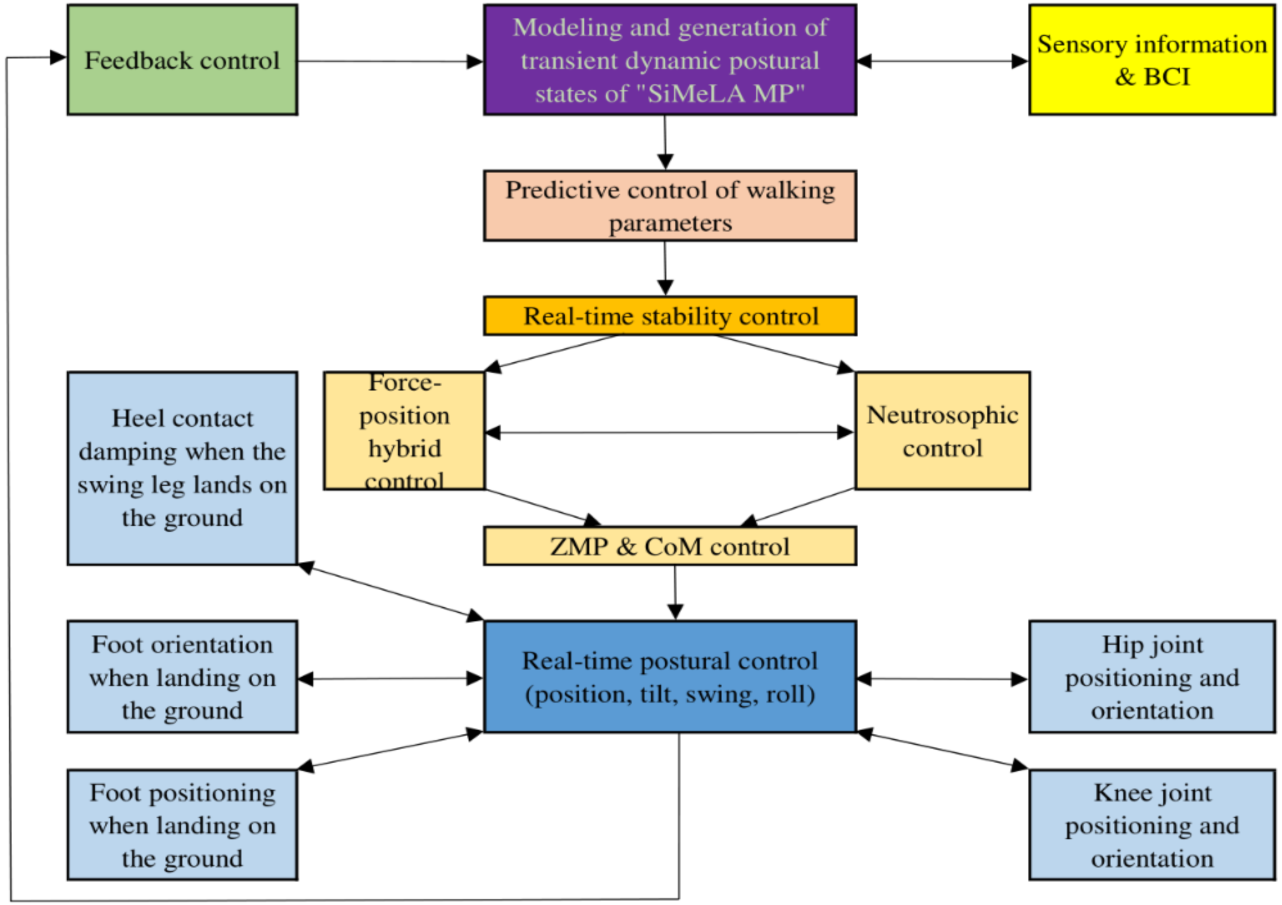
# CHAPTER 3
# CONTROL SYSTEM ARCHITECTURE OF THE SiMeLA MP ROBOT




**AWR stability control strategy in the virtual environment**

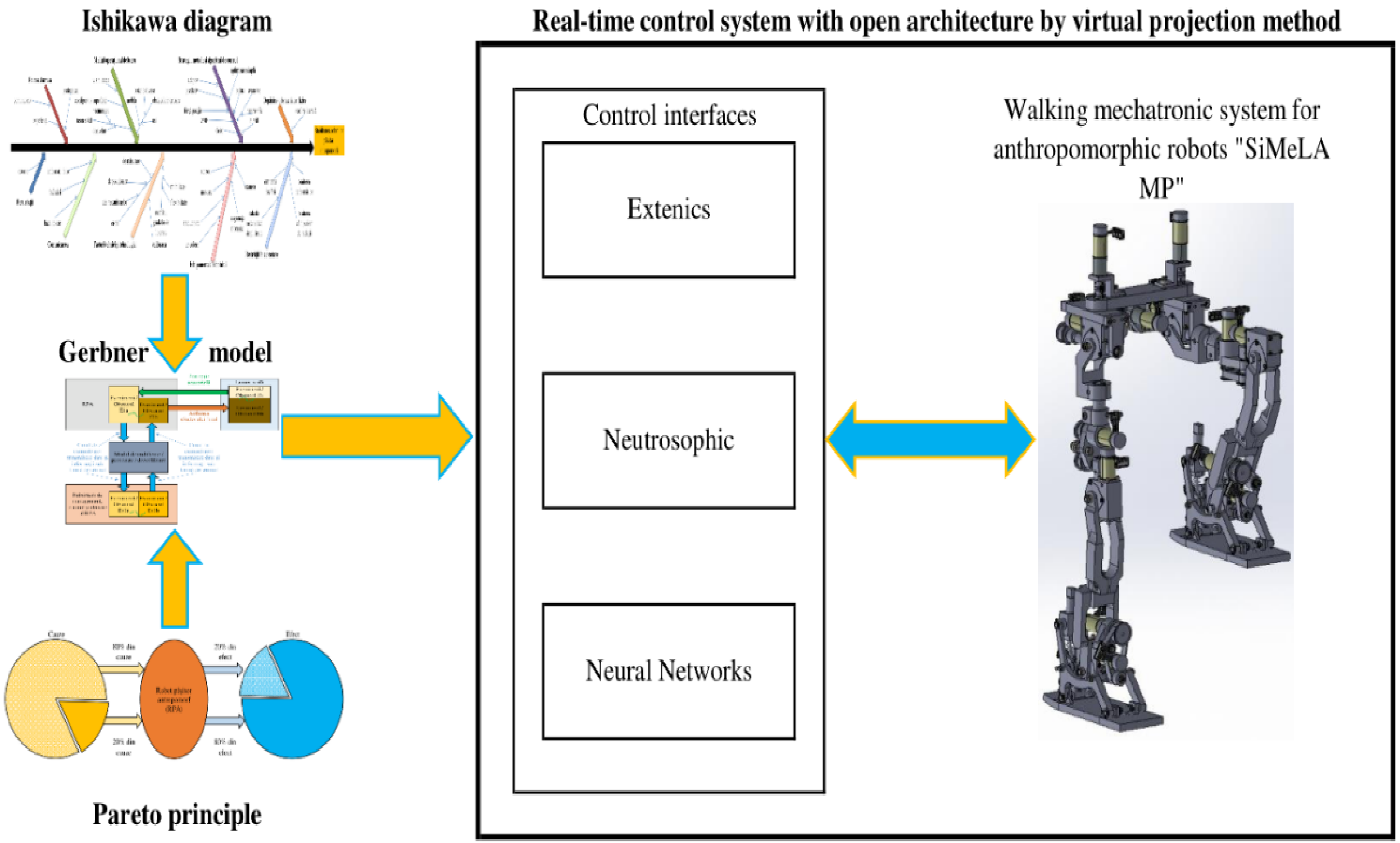
- AWRs are multifunctional systems with nonlinear dynamics and complex tasks; controlling them is difficult and challenging

# CONTROL SYSTEM ARCHITECTURE OF THE SiMeLA MP ROBOT




**Architecture of the control system for the SiMeLA MP robot**

- SiMeLA MP robot has multifunctional systems with nonlinear dynamics and complex tasks; controlling them is difficult and challenging




The intelligent interfaces for stability control integrated **VIPRO CS** architecture

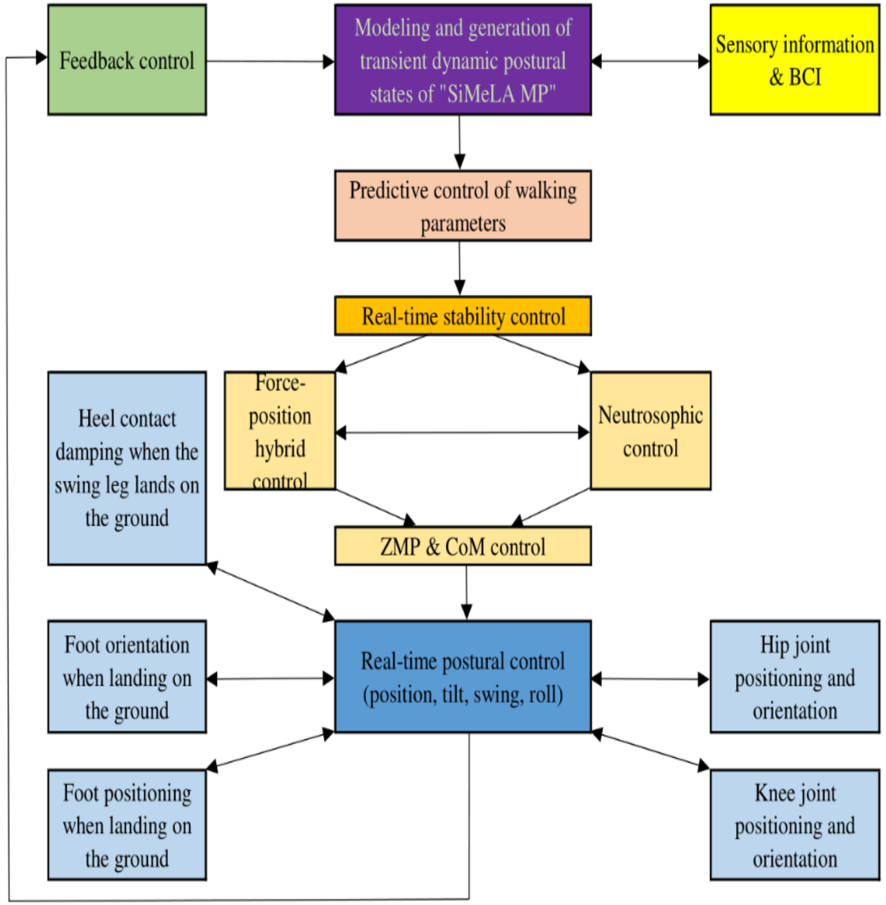
- The AWR stability control is based on perception, processing of series of values of measured parameters, environmental conditions, communication and reaction of mechatronic systems.

# CONTROL SYSTEM ARCHITECTURE OF THE SiMeLA MP ROBOT

## The components of the control system architecture:

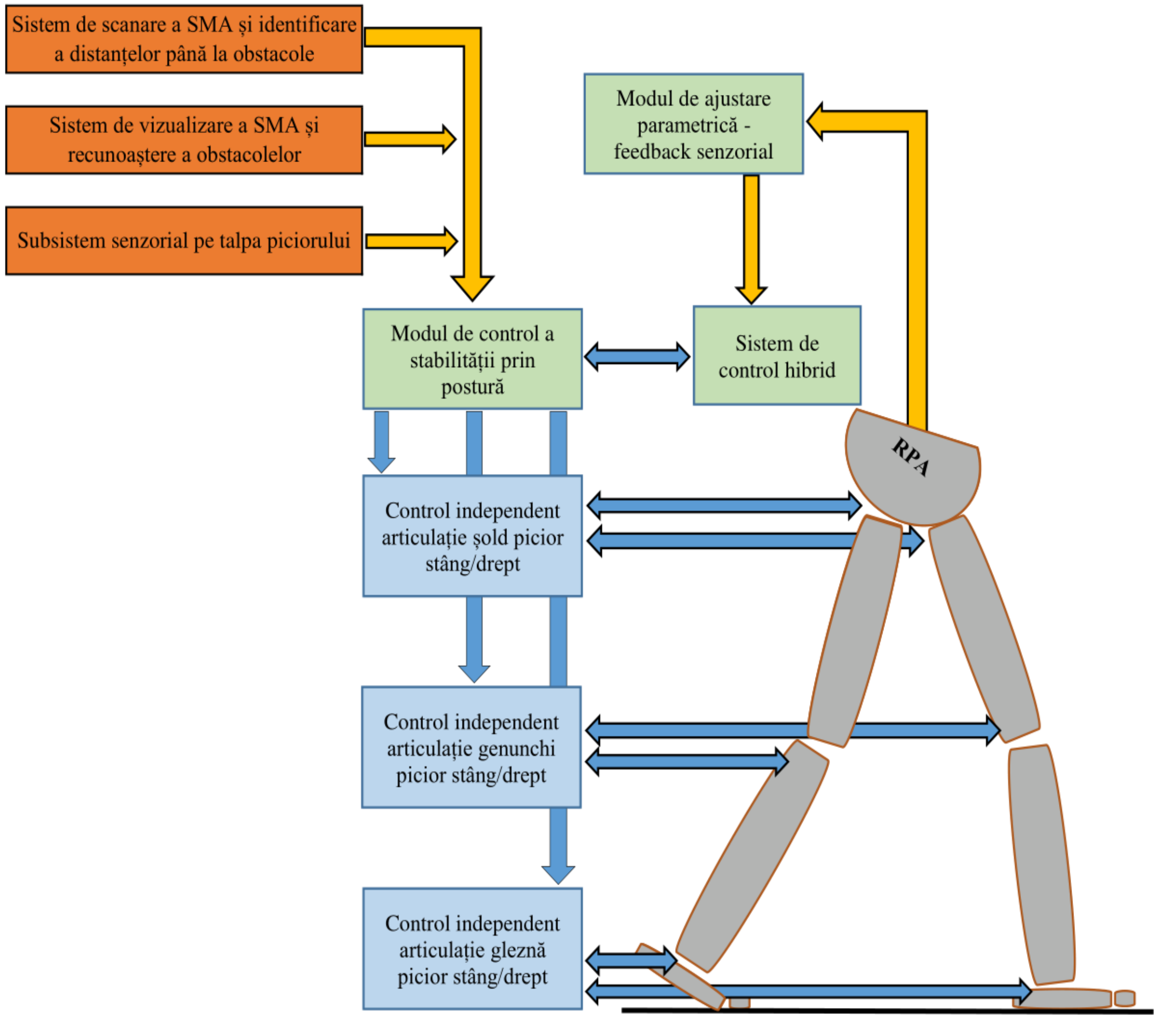
- **new flexible control algorithm** with high impact on robot stability during walking through completely unknown, bumpy and obstacle environments, which ensures normal walking by positioning and postural orientation at the level of mechanical assemblies, foot landing motion braking and heel contact shock absorption with the support surface,

- **hybrid control method -** decentralized force-position at the joints by adding neutrosophic control to obtain a precise posture,




**Architecture of the control system for the SiMeLA MP robot**

# CONTROL SYSTEM ARCHITECTURE OF THE SiMeLA MP ROBOT




**Perception-based hybrid control strategy**

The canonical equations of motion of Hamiltonian mechanics:

$$\frac{dp_i}{dt} = -\frac{\partial \mathrm{H}}{\partial q_i}$$

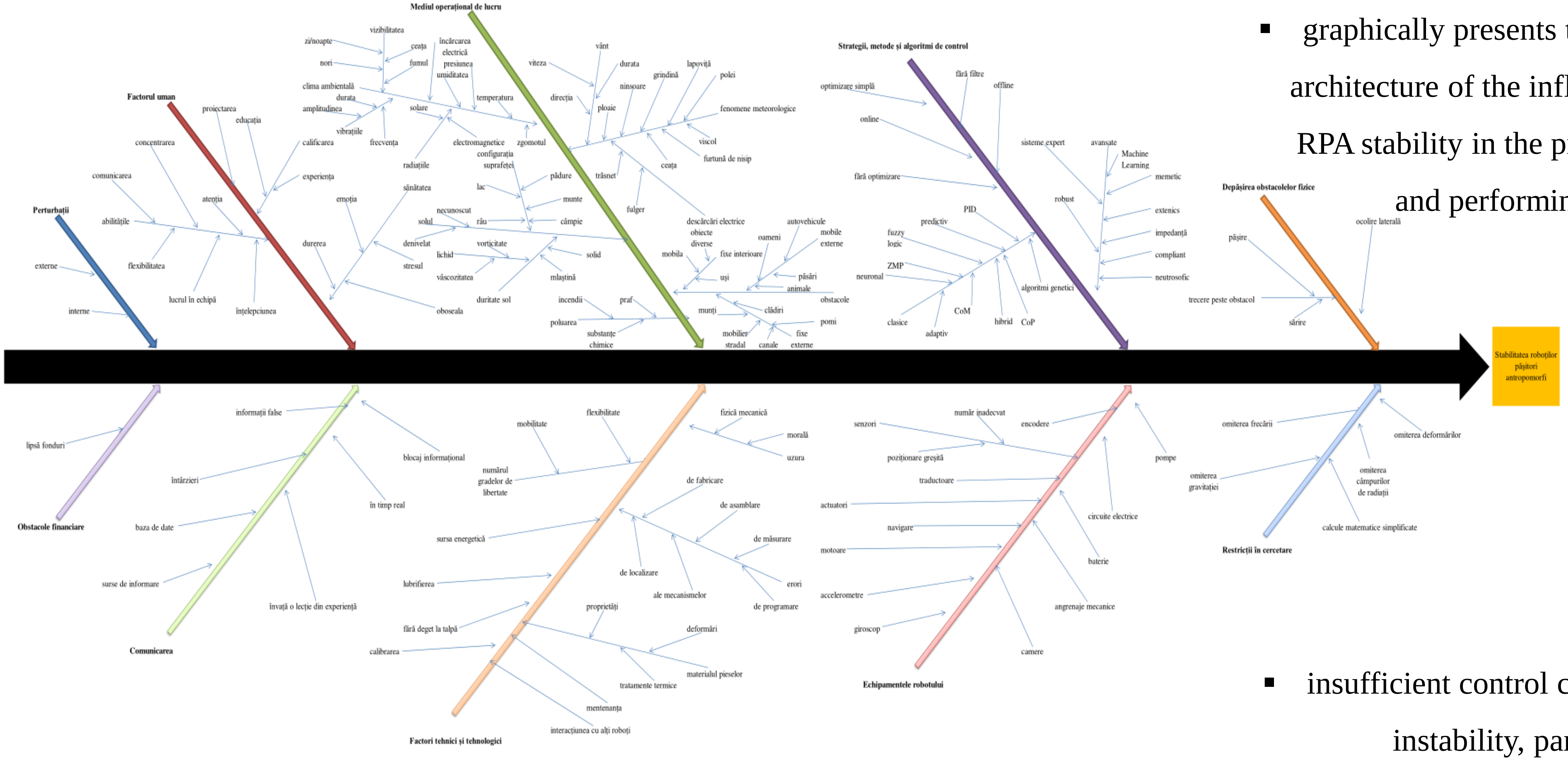
$$\frac{dq_i}{dt} = +\frac{\partial \mathrm{H}}{\partial p_i}$$

$$\mathrm{H} = \mathrm{T}_C + V_P$$

General equation of motion of SMD:

$$M(q)\cdot\ddot{q} = -C(q,\dot{q})\cdot\dot{q} - G(q) - J_C(q)^T\cdot F_{ext} + \Upsilon$$

# CONTROL SYSTEM ARCHITECTURE OF THE SiMeLA MP ROBOT

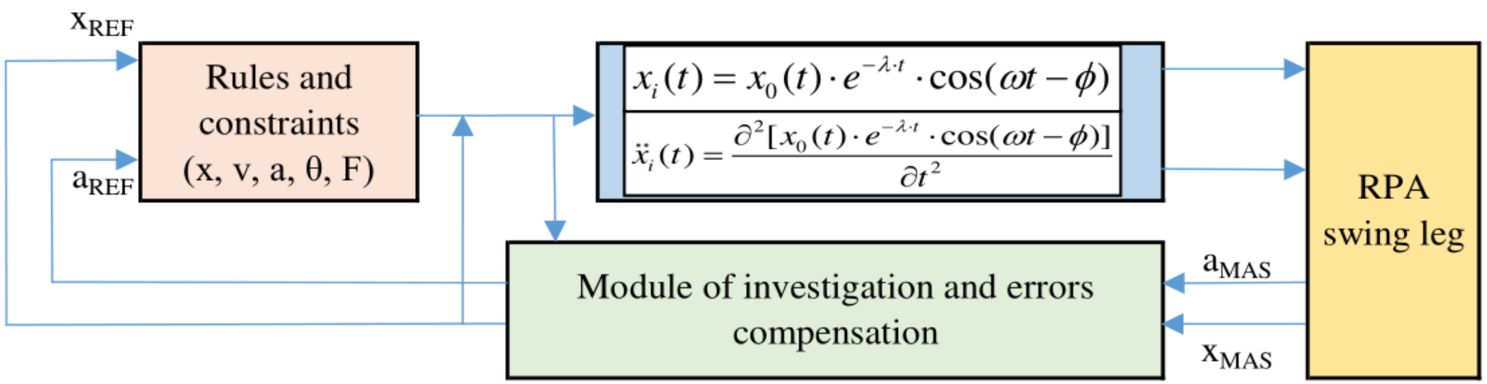



- graphically presents the cause-ordered architecture of the influencing factors of RPA stability in the process of stepping and performing the task

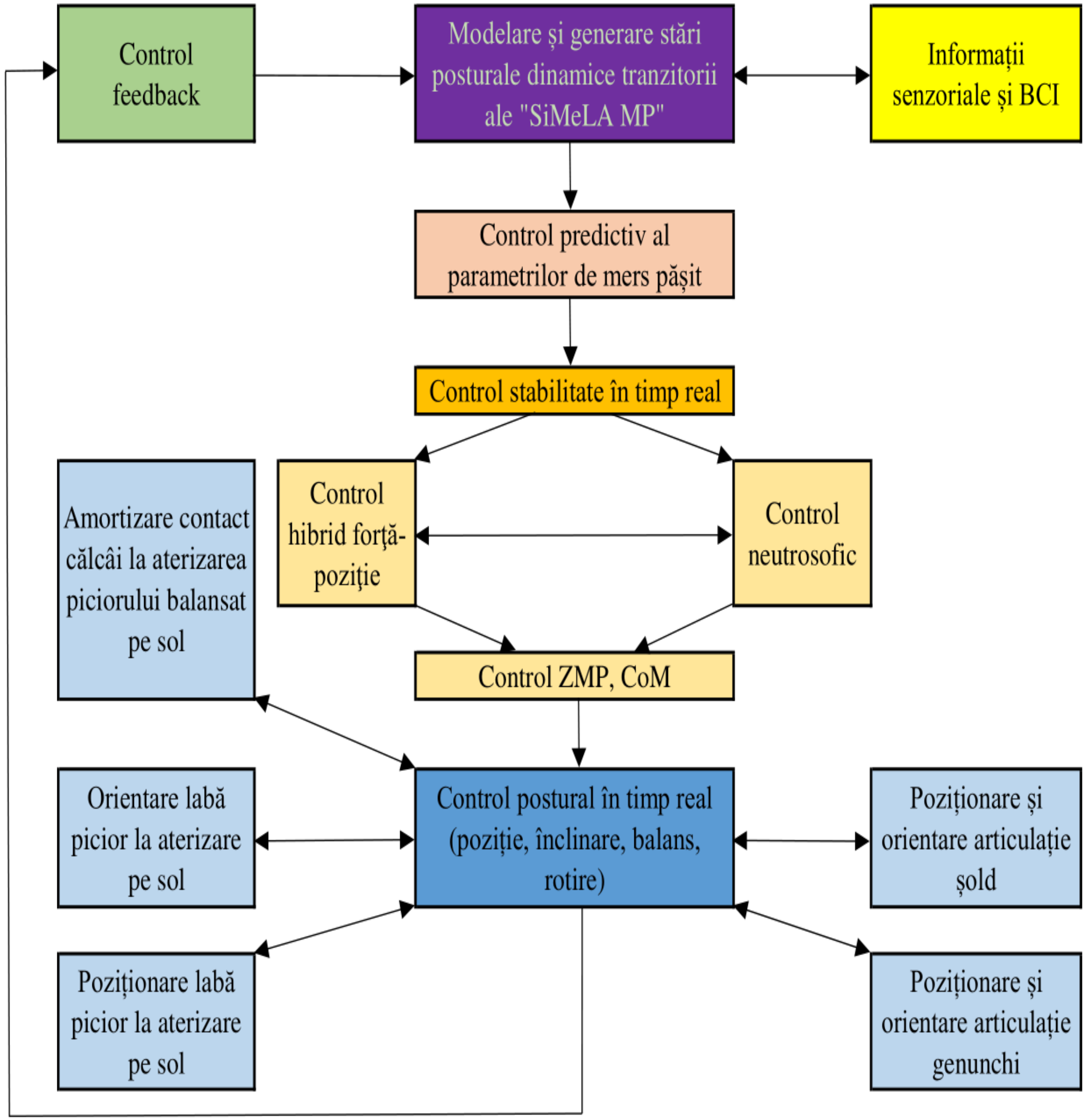
- insufficient control causes imbalances / instability, partial or total.

**Ishikawa diagram associated with AWR stability control**

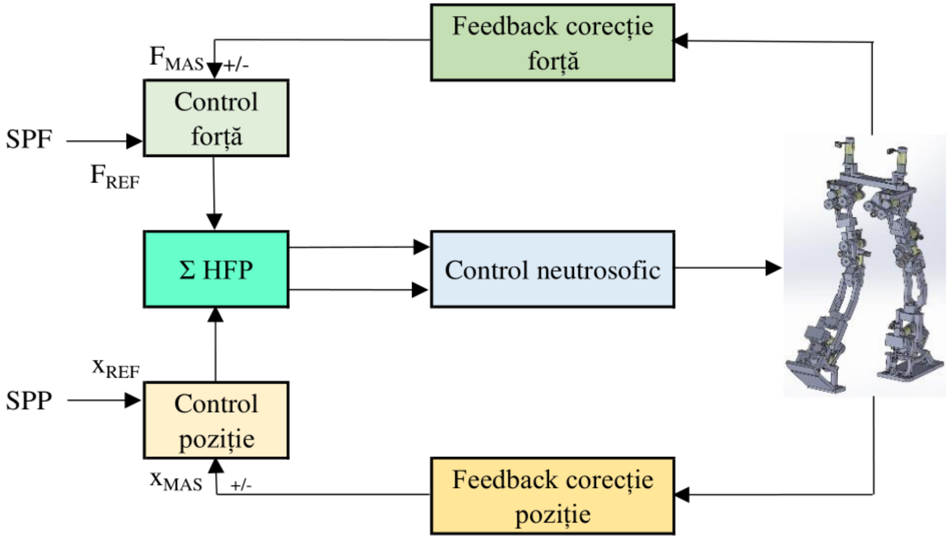
# CONTROL SYSTEM ARCHITECTURE OF THE SiMeLA MP ROBOT



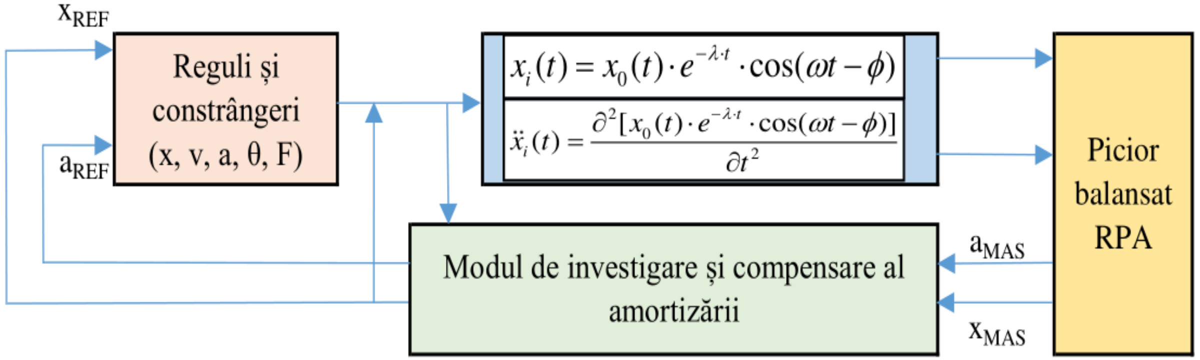

**Control strategy for shock damping at contact of the heel of the foot with the ground**




**Architecture of the SiMeLA MP robot motion control system**

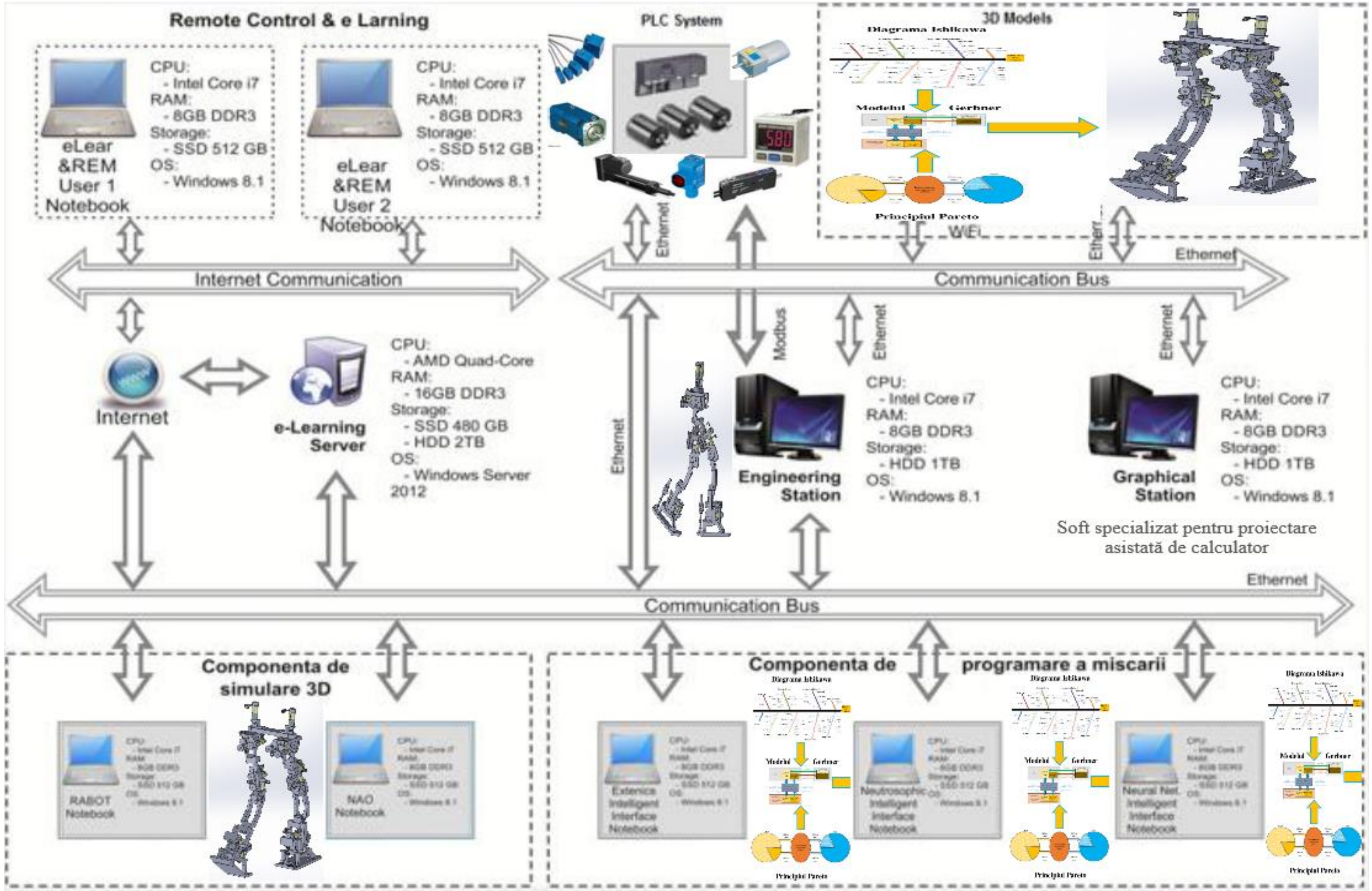



**Hybrid force-position control scheme and neutrosophic decision**

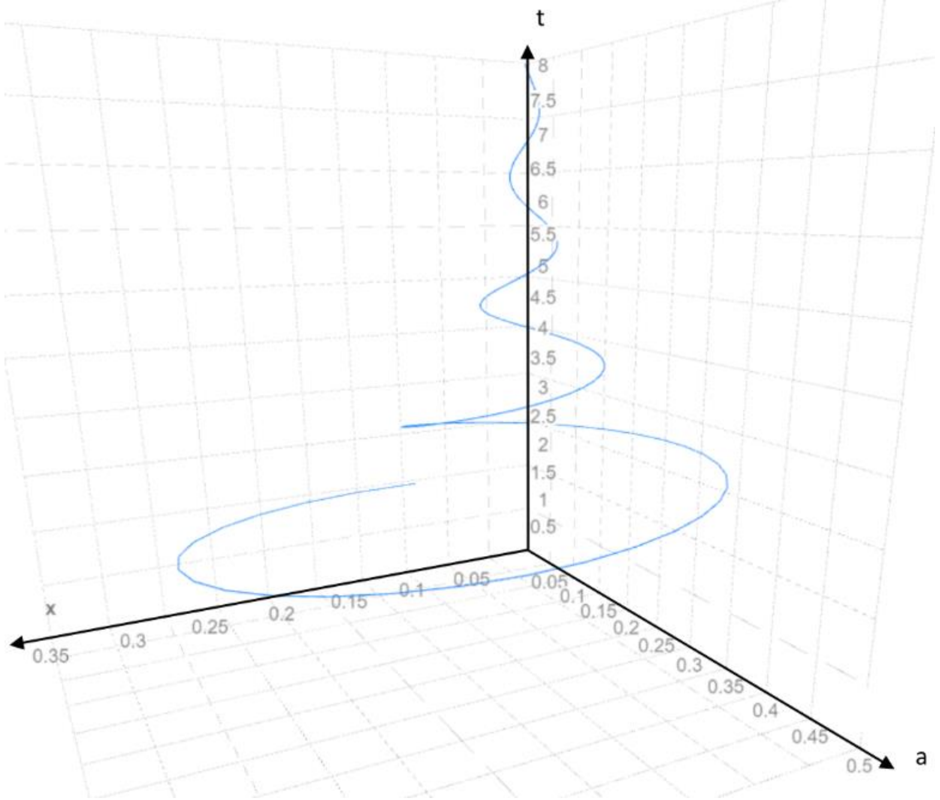



**Control strategy for shock damping at contact of the heel of the foot with the ground**

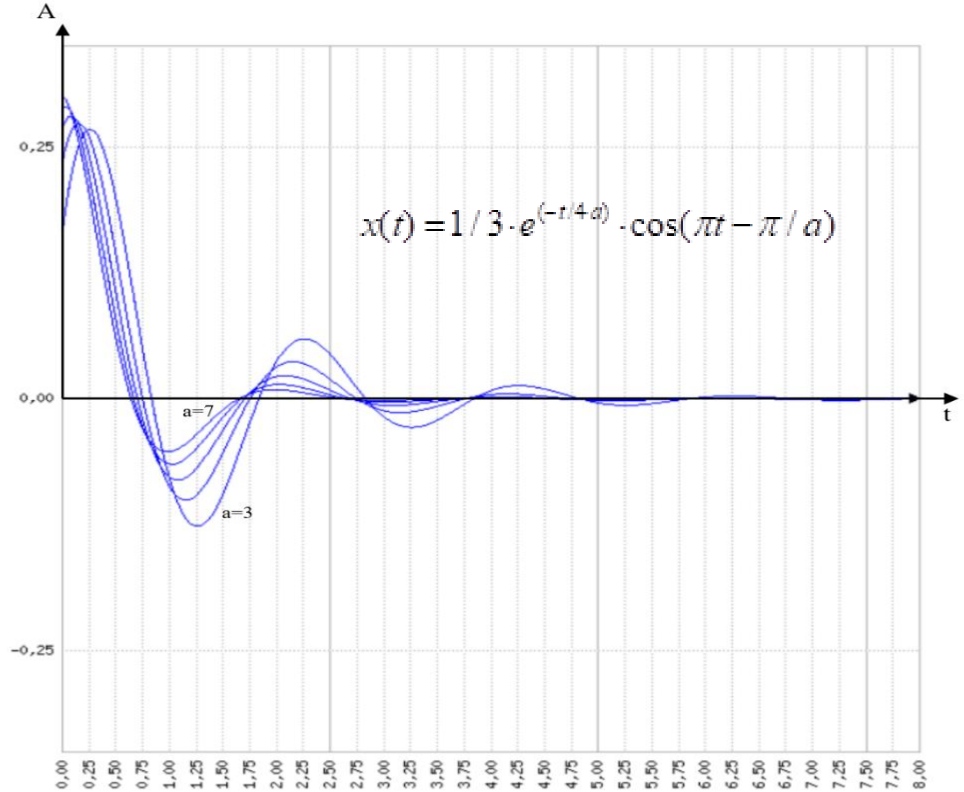
# EXPERIMENTAL RESULTS




**Configuration of the VIPRO platform for SiMeLA MP stability control**

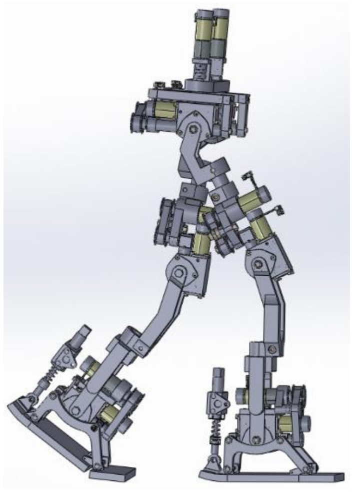


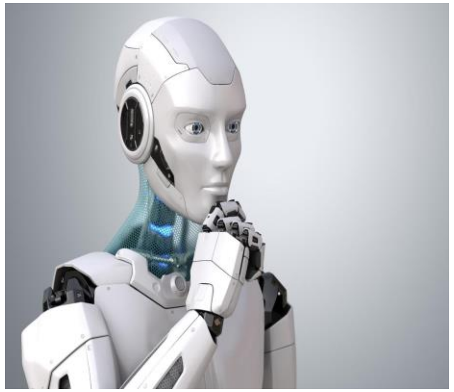

**Evolution of the position and acceleration of the characteristic point of the foot of the robot until the contact of the heel with the ground**



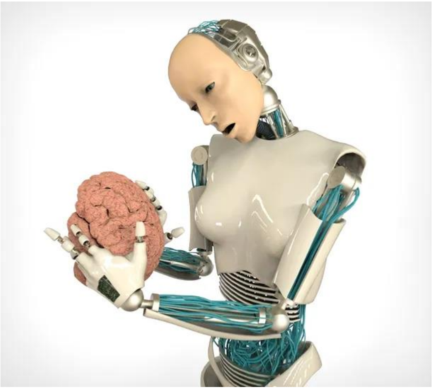

**Controlling the shock absorption of the robot's heel in contact with the ground**

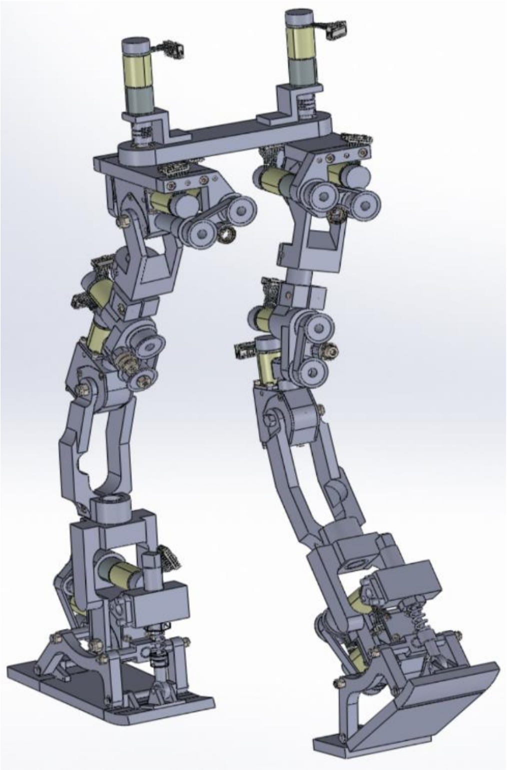
- the values of correction factor are between a=3 and a=7, with a step of 0.5, so the damping basically has ten stages of attenuation applicable depending on the nature of the soil
- the wide range of values ensures locomotion continuity and smooth step





# CONCLUSIONS





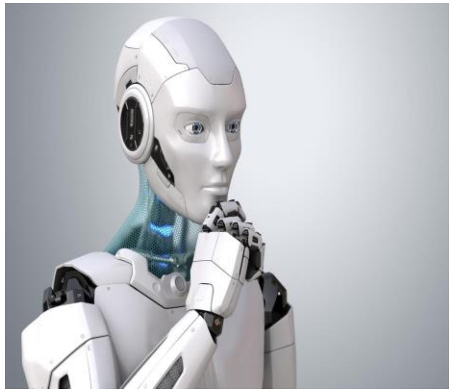
The results led to increased flexibility at the joint level and functional stability of the model at the level of geometric and angular positions, ensuring a smooth and uninterrupted gait.

The new advanced intelligent AWR stability control method developed through a flexible algorithm based on force-position and neutrosophy ensures normal smooth walking in the conditions of movement in an unstructured indoor terrestrial environment with accidental ground bumps and obstacles.

The wide range of values ensures locomotion continuity and smooth step.

The novelty element is the fact that at the level of the hip, knee and ankle joints fine neutrosophic control stages are introduced in the sagittal and frontal plane to bring extra safety when the robot steps in an unknown environment with bumps and obstacles.

SiMeLA MP



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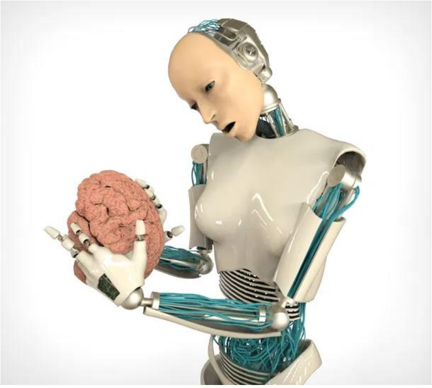
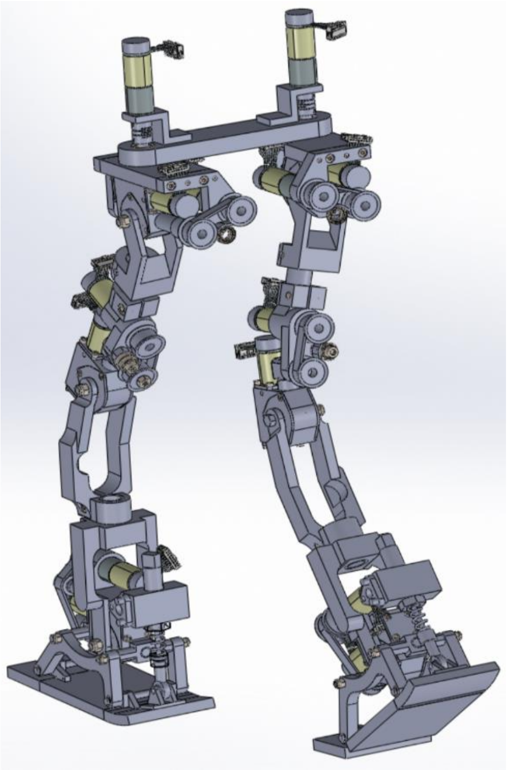


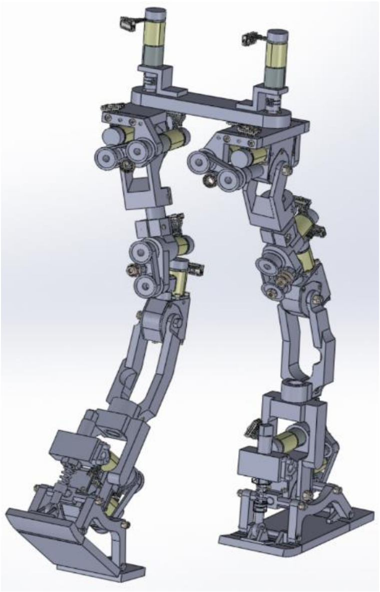
The development of a new family of functional with variable impact for braking the landing movement of the robot leg and damping the shock upon contact with the support surface.

Applying the V&M virtual projection method, the correctness of the sequence was demonstrated of transient states of the elements of the mechanical assemblies, increased flexibility at the level of joints and functional stability of the model at the level of geometric and angular positions ensuring a smooth, uninterrupted walk.

The anthropomorphic walking robot SiMeLA MP, ensures high availability for movement, high mobility of mechanical assemblies, in conditions of stability and balance, proven by complex, difficult positions.



SiMeLA MP



# THANK YOU
# FOR YOUR ATTENTION!

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