

# Investigation of Time and Energy Consumption using the Physical Model

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# Flexible **physical model**

An flexible **physical model for research robots** from the authors is developed and proposed .

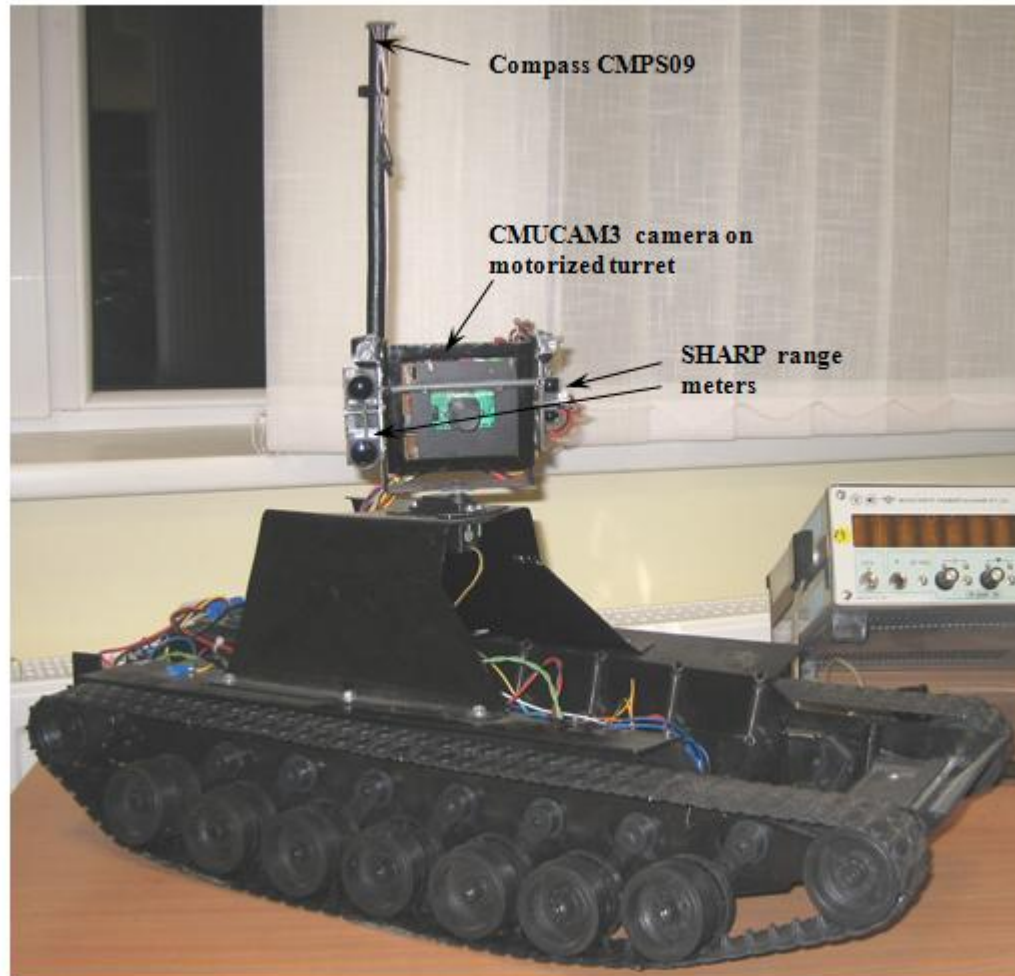
Physical model is used for **autonomous unman outdoor mobile robot** development:

- - software design for particular non-military robots,
- - real- time process investigation
- - energy consumption investigation
- - students education

# Different robots

- Well-known autonomous non-military *outdoor* research robots SegwayRMP400, Seekur and **Robotino** are **wheel drive based** and are not useful for mobile robots in **hilly uneven hard environment**. For such conditions different military robots **legged** and **caterpillar** track are proposed.
- Ours autonomous mobile robot physical model **platform is developed for unman *caterpillar track* motion**.
- **Physical model** structure is modular and flexible.
- **Star topology sensor network** with central node **Atmega32** is used.

# Implementation of flexible **physical model**



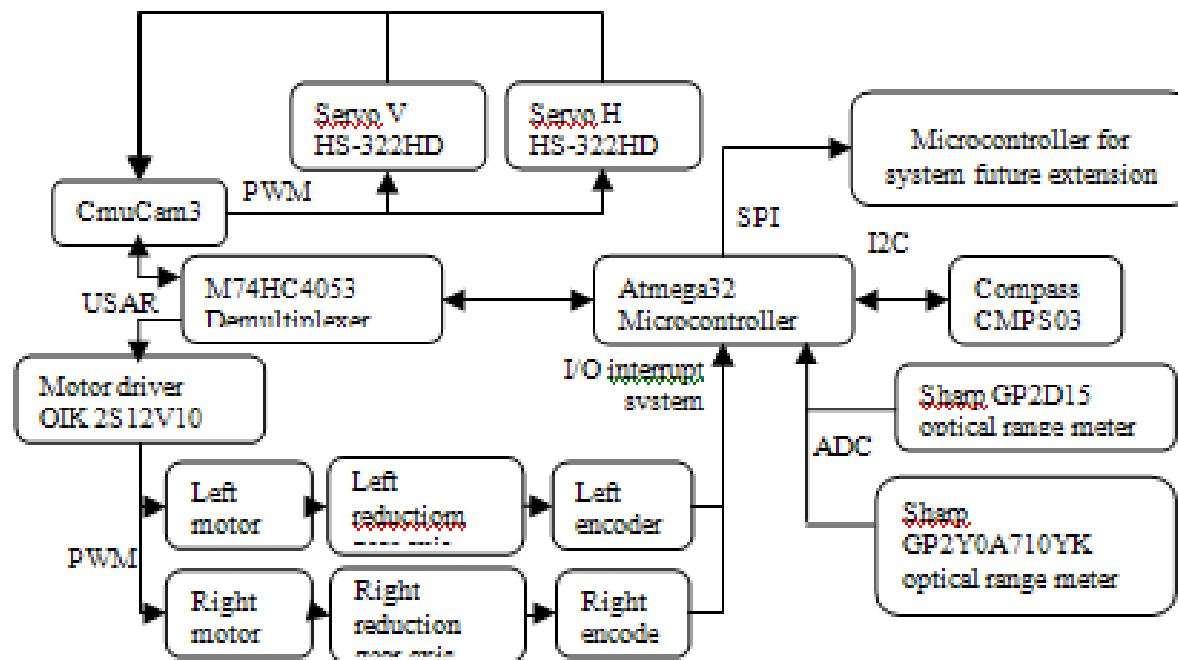
# Sensor system

- **Sensor system** for navigation, space investigation and surrounding objects' characteristic perception was created. It includes:
  - - image recognition system,
  - - digital compass,
  - - range measuring system,
  - - traveled distance and deviation from the route measurement module.

# Specific sensor systems

- **Objects' recognition**, their **color** and **size** determination is being held using an image recognition system - **CmuCam3 module** built on Phillips LP2105 Arm7 processor and Omni vision OV7630 CMOS sensor base. Image recognition module has a built-in **servo controller** which can drive up to **four servomotors**. It is used to direct robot's turret in a required direction.
- Two types of sensors were tested to find an optimal method of **distance measurement**:
- **Ultrasonic** range measuring sensor SRF08 is able to determine distances for objects detect objects on distance from 3 centimeters to 6 meters;
- **Optical** sensor system consists of R316-GP2Y0A710YK module measuring distances from 100 centimeters to 550 centimeters and R144-GP2Y0A02YK module measuring distances from 20 centimeters to 150 centimeters.

# The structure of the system



Digital tilt compensated **compass** CMPS09 is used to **determine a direction**. It has **magnetometer** and **accelerometer** sensors inside. For the future robot physical model extension GPS and IMU integrated navigation solution is planned

# Performed tasks

The developed mobile physical model performs **tasks**:

- the object search
- object coordinate determination,
- navigation map's compilation,
- the shortest circular route computation,
- passing along the route.

## **Route planning algorithms**

- Investigated and analyzed route planning algorithms include: method of defining routes, Brute-force and **Ant-colony algorithms**.
- **Simulator** on Java language was developed for the algorithm accuracy and performance comparison.
- **Ant-colony algorithm** seems to be the best choice. The Ant-colony algorithm simulates the ant colony behavior within an area **finding the shortest route** with a help of ***pheromone***. During the initialization stage ants are uniformly distributed over the vertices of a graph.

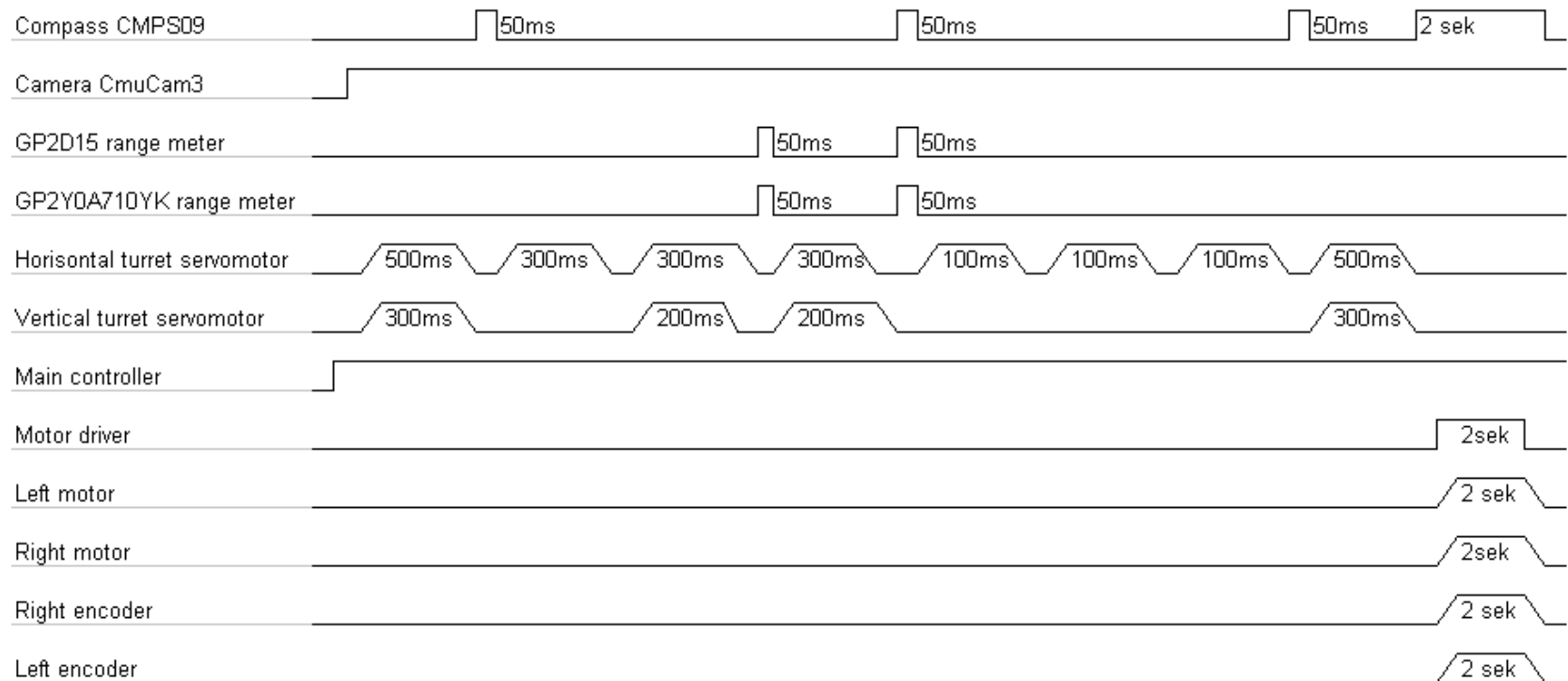
# Actions

In this state the following actions are performed:

- Camera rotation to the extreme left position;
- Azimuth is read from the digital compass;
- Camera starts to search for the objects;
- If no objects were found, camera turns to the right by 30 degrees;
- If objects were found, camera starts turning to point in a direction of the nearest object to the right of the received frame's center;
- If camera points to the found object, azimuth is read from the digital compass and distance is read from the optical sensor system;

# The time diagram of the activities

- **The time diagram** describes an activity of the robot located in the **initial position** while it is scanning the nearby territory searching for the objects



# Real time processes

- **Real time processes :**
- Image processing rate  $\approx 300$  ms/frame;
- Range measurement rate  $\approx 50$  ms/measurement;
- Range measurement uncertainty  $\pm 5$  cm/m;
- Azimuth measurement rate  $\approx 50$  ms/measurement;
- Azimuth measurement uncertainty  $\pm 5$  deg;
- Maximum movement speed  $\approx 1$  m/s;
- Maximum turning speed  $\approx 1/3$  turn/s.

# Evaluation of energy consumption

## Energy consumption:

- CPU *Atmega 32* ( $5V \cdot 50ma = 0.250W$ ); 2 range meter *GP2* ( $2 \cdot 5V \cdot 50ma = 0.500W$ ); 2 compass *CMPS09* ( $2 \cdot 5V \cdot 25ma = 0.250W$ ); camera *CmuCam3* ( $10V \cdot 450ma = 4.5W$ ); 2 camera motor ( $2 \cdot 5V \cdot 750ma = 7.5W$ ); motor driver ( $5V \cdot 50ma = 0.250W$ ), 2 motor ( $2 \cdot 10V \cdot 3.50a = 70W$ ); maximal energy consumption:  $\sum_{ei} \sim 83W$ .
- Power supply Li-Po 4500mAh 12,4V battery is used. The battery can provide up to **45 minute of continuous activity of the robot.**

**Thank you for attention!**

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