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.

<table>
<thead>
<tr>
<th>Component</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compass CMPS09</td>
<td>50ms</td>
</tr>
<tr>
<td>Camera CmuCam3</td>
<td></td>
</tr>
<tr>
<td>GP2D15 range meter</td>
<td>50ms</td>
</tr>
<tr>
<td>GP2Y0A710YK range meter</td>
<td>50ms</td>
</tr>
<tr>
<td>Horizontal turret servomotor</td>
<td>500ms</td>
</tr>
<tr>
<td>Vertical turret servomotor</td>
<td>300ms</td>
</tr>
<tr>
<td>Main controller</td>
<td></td>
</tr>
<tr>
<td>Motor driver</td>
<td>2 sek</td>
</tr>
<tr>
<td>Left motor</td>
<td>2 sek</td>
</tr>
<tr>
<td>Right motor</td>
<td>2 sek</td>
</tr>
<tr>
<td>Right encoder</td>
<td>2 sek</td>
</tr>
<tr>
<td>Left encoder</td>
<td>2 sek</td>
</tr>
</tbody>
</table>
Real time processes

- **Real time processes:**
- Image processing rate ≈ 300 ms/frame;
- Range measurement rate ≈ 50 ms/measurement;
- Range measurement uncertainty +/- 5 cm/m;
- Azimuth measurement rate ≈ 50 ms/measurement;
- Azimuth measurement uncertainty +/- 5 deg;
- Maximum movement speed ≈ 1 m/s;
- Maximum turning speed ≈ 1/3 turn/s.
Evaluation of energy consumption

Energy consumption:

• CPU Atmega 32 (5V ∙ 50ma = 0.250W); 2 range meter GP2 (2 ∙ 5V ∙ 50ma = 0.500W); 2 compass CMPS09 (2 ∙ 5V ∙ 25ma = 0.250W); camera CmuCam3 (10V ∙ 450ma = 4.5W); 2 camera motor (2 ∙ 5V ∙ 750ma = 7.5W); motor driver (5V ∙ 50ma = 0.250W), 2 motor (2 ∙ 10V ∙ 3.50a = 70 W); maximal energy consumption: $\sum_{ei} \sim 83$ W.

• 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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