DEVELOPMENT OF MOBILE RESEARCH ROBOT

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INTRODUCTION

New mobile research robot development for education and training purpose is urgent, despite now there are different ready-made research robots which were purchased primarily by researchers. Before new commercial research of autonomous robot for hard and unstructured environment design began, there were different significant problems necessary to solve: position estimation, obstacle avoidance, motion trajectory planning and map building, timely and energy consumption estimation.

Historically the term — autonomous mobile unmanned robot implies a real time system (RTS). Often systems are estimated and classified as hard, firm or soft RTS. The required deadline is the decisive subdivide factor. But it is the determined parameter of application and environment. When the deadline failure threatens human life, the hard design system is obligatory. In other kinds of applications the permissible complete task execution time (ET) can be firm but at the same activity (phase) the RTS can be soft. The hard system can be considered as a special case of soft RTS.

TIMELINESS ESTIMATION

Autonomous mobile unmanned robots' general structure includes: one central unit CU (main processor), clusters of sensors Sn and actuators Ac with interface nodes. All nodes and information lines can be characterized with some real time properties (time delay, throughput, security).

Activity execution phases for an unmanned outdoor Robot is represented by N+1 main finite automata states and different kinds of execution time intervals $T_0, T_1, \ldots T_k, \ldots T_N$. Phases k can include particular phases or a number of N_k states and execution cycles or activities t_{kw}. Execution cycles can be performed concurrently or sequentially. Information from different sensors can be obtained simultaneously. Concurrency of mechanical actuator and electronic operation execution is especially important for optimal real time robot design.

Robot algorithm divided in phases and each time consumption of each phase is being weighted.

A deadline can be determined for each execution phase. When sequence of all of the phases can be determined in $WCET_i$ (worst-case execution time) - the robot can be determined as hard RTS.

To compare and estimate different robot realization structures it is necessary to select the same test environment.

For sophisticated autonomous mobile robot timelines with task completion slack time, start time and soft deadlines utility accrual UA approach can be used. The *Utility* (U) depends on the activity's completion time for phases T_i and particular cycles t_k. These soft time constraints are subject to optimality criteria such as completing all time-constrained activities as close as possible to their optimal completion time — so as to yield maximal collective utility. Time/utility functions is a generalization of the deadline constraint, specifies the utility to the system resulting from the completion of activity as a function of its completion time.

Activity *ji* utility (*U*) calculation is useful to compare the realization time t_{ji} and some soft deadline d_s (Figure 1.).

This soft deadline depends on environment where is acting the autonomous mobile robot. While developing our research robot physical model the d_s usually was equal to image processing delay.

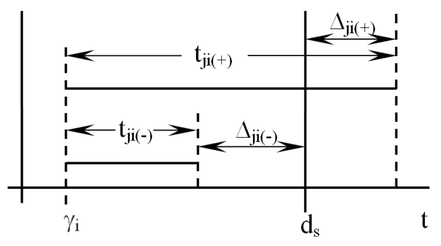


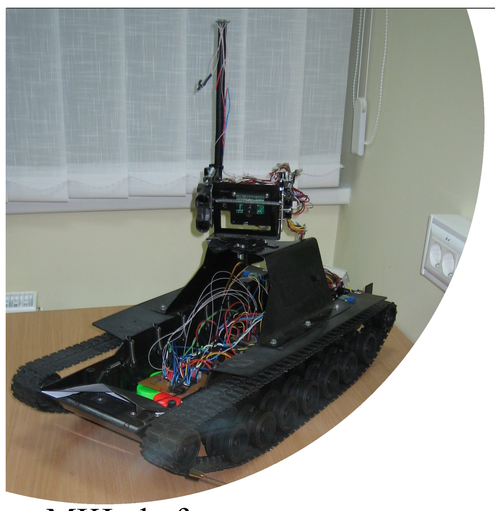
Figure 1. Activity j realization with deadline d_s

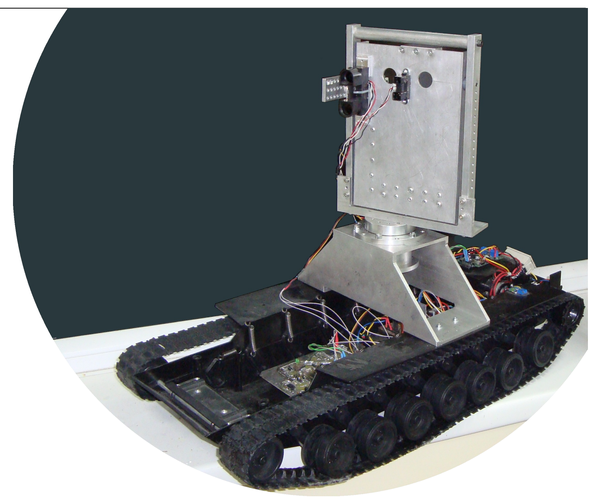
Performing any tasks there is some probability $p_{11(+)}$ of missing the deadline d_s. For the activity *ji* utility calculation, this time ($t_{ji(+)}=d_s+\Delta_{ji(+)}$ is $\gamma_{ij}\tau_{ij(+)}d_{sij}$) designated, γ_{ij} - task starting time point.

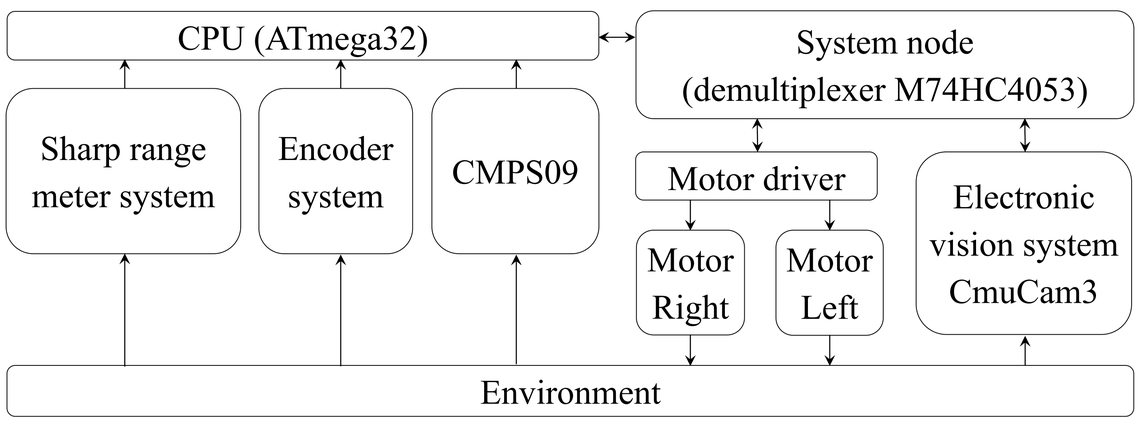
DEVELOPED TEST PLATFORMS

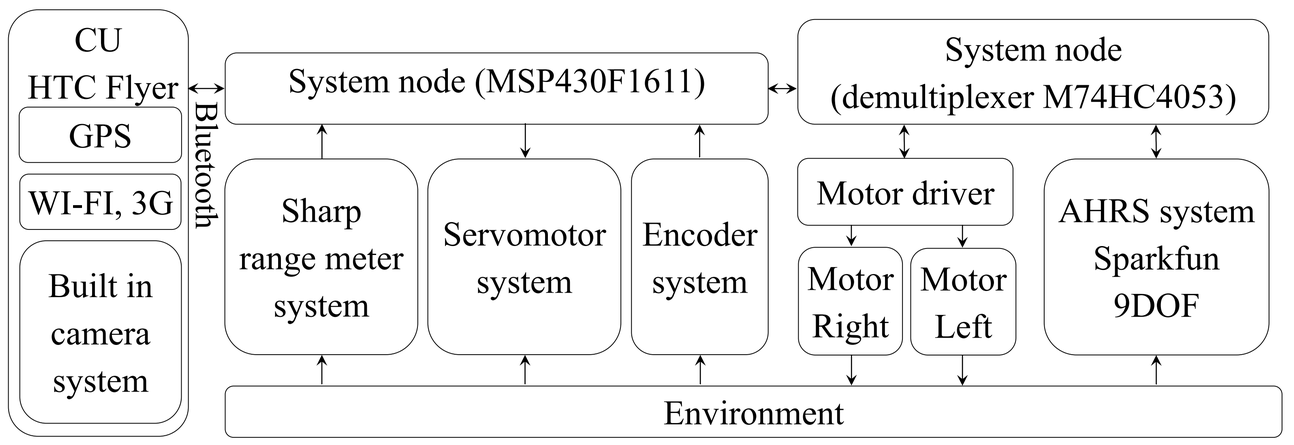
MKII platform benefit over MKI platform:

- Video camera module. MKI used CmuCam3 built by Carnegie Mellon Univercity. MKII uses placed on HTC Flyer High-Quality 8Mpix camera module.
- Navigation system. For the navigation purposes first robot used electronic compass CMPS09, encoder system, and range finders. New system uses Sparkfun 9DOF AHRS module instead of CMPS09.
- CU. Main control unit of the first robot was ATmega32. As a control unit for a new robot HTC Flyer was chosen because of its powerful processor.
- Communication abilities. MKII platform is capable of communication using 3G or Wi-Fi networks. It helps an operator to control robot and get telemetry data from any place in the world where the internet connection is available.


MKI platform


MKII platform





CONCLUSIONS

For the new autonomous mobile research robot design, the real time problems are significant and it is necessary to solve it in estimated time. For timely analysis, an autonomous robot's structure is based on a single main processor, clusters of sensors and actuators with its interface nodes. In different robot's activity phases the *time/utility* function TUF and utility accrual UA criteria are selected.

For time and energy consumption experimental estimation robot's physical model is used. This model is advisable for student education.

The new autonomous mobile robot is designed using wireless technology.

FURTHER WORK

Development of intellectual algorithm for mobile robot task planning.

Development of intellectual algorithm for mobile robot adaptation in the hard environment.

Development of ground robot — air robot system.

Development of endurant mobile robot capable to accomplish tasks in the hard environment.

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