Mobile node implementation for WSN applications

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***Abstract*—** The approach is front towards some directions: mobile sensor networks, wireless communications, localization and tracking, data acquisition. The work goals are the designing, the implementation, and the validation of a modular, adaptable system for identification, tracking, localization and data acquisition through sensors network whose nodes are situated on moving objects (platforms). Because of the mobility, transmission of data between the nodes is made through radio communications (wireless). Both concepts, the sensors network and the wireless communication, are parts of so called integrated systems (embedded systems). Measurements provided by sensors are uncertain, so they are capable to give parameter estimation only. The modular node can't uphold on one sensor to supply enough information and, therefore, it must be used the fusion of data from several sensors in order to obtain more precise information. The paper presents a model of sensorial fusion, for identification and localization task, within a mobile node. The goal of the equipment, which is proposed for research and developed in an experimental version, is to associate, based on DSP architecture, modular procedures of signal processing (data acquisition, tracking, localization and communication). These procedures, which can be configure upon request, are meant to transmit numerical data through un-wired support, especially over wireless sensor networks (WSN). Each of the sensors groups, together with locally attached system for processing and communication from object in motion, becomes an intelligent node. The intelligent nodes communicate between them and with a priority node, named network management node. Two procedures for optimizing network topology and for tracking mobile nodes in this network, both ensuring minimum power consumption, are discussed. The solution for node safety displacement consists in two levels implementation: a low level section (the sensory level) and a high level section (the fusion data level). There are four main hardware modules incorporated in the intelligent mobile node structure: the communication module, the video module the data acquisition module, and the power module. Some detail on the mechanical, electrical and functional characteristics of this intelligent sensor network node and future possible applications are finally discussed. The simulations are made in virtual and real environment. The validation allowed the implementation of a prototype, able to be configured upon request, by the economic unit. Thus, the prototype was configured and experimented for two applications: a mobile robot network and a network of mobile objects for quality and safety of the environment.

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I. Mobile, Wireless Sensor Networks

Wireless sensor networking (WSN) is one of the most essential technologies for implementation of ubiquitous computing. Sensor nodes, are tiny devices equipped with one or more sensors, one or more transceivers, processing unit, storage resources, and, possibly, actuators. Sensor nodes are organized in networks and collaborate to accomplish a larger sensing task. Sensor networks are applied in variant environments, i.e. health care, military, environment, warehousing and transportation management [1], [2], [3], [4], [5]. The sensor networks usually share the same communication channel. Sensor nodes have limited in power, computational capacities, memory and short-range radio communication ability. The limited battery life of sensor nodes raises the efficient energy consumption as a key issue in wireless sensor networks. The main objective of our research consists of a conceptual model and architecture elaboration for mobile sensor nodes based on internal processing theory by complementary data fusion, and a functional model, embedded system type, for tracking, localization, data acquisition and processing, communication and remote visualization. The functional model which is a modular, demand configured one, has high technical and economical performances.

For fulfilling the tasks, the system has to be based on the sensorial data fusion from multiple sources. Firstly, multiple sensorial measurements can be mixed to complete each others, which is important when the sensors interact with just a part of the environment. Also the sensorial measurements can cooperate to obtain a value that is more precise then any of the two separate measurements.

Because the information from sensor is incomplete and uncertain, it is essential for the system to provide redundant information from more sensors. Generally there are distinguished three types of sensorial data fusion:

-Complementary fusion: fusion of incomplete sensorial measurements from several separate sources;

-Competitive fusion: fusion of redundant sensorial measurements from more sources;

-Cooperative fusion: fusion of physical measurements after or during conversion time.

The network is composed by moving objects (modular nodes) with time depending topology, and therefore, with geometrical and temporal node coordinates (Fig. 1).

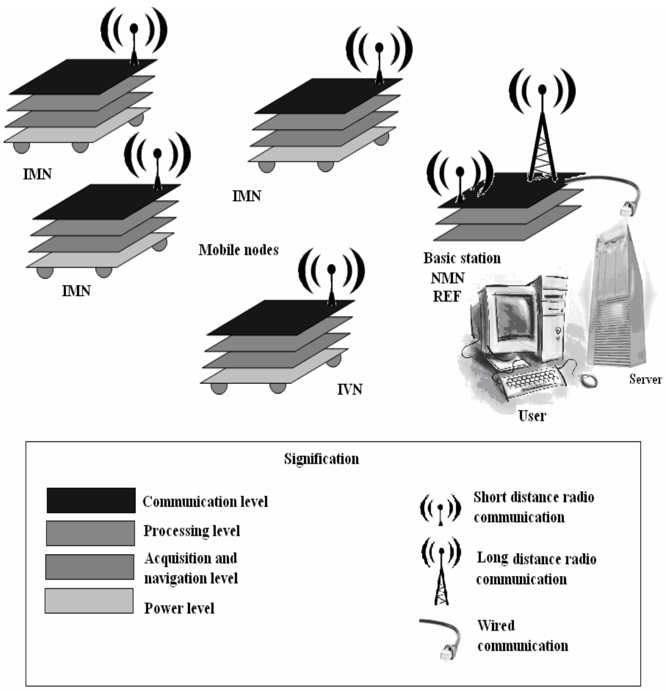

Fig.1 Mobile sensor network

They are endowed with complex programmable equipments, low power consumption, able to acquire and to process data, to interact with other nodes in order to identify the position, and to communicate wireless. The abbreviations in Fig.1 are the following: NMN - network management node, IMN - intelligent mobile node, REF – reference system for tracking and localization, IVN - interactive visualization node (mobile type).

The paper describes the modular implementation of a wireless sensor mobile node (IMN) with specific facilities for integration in a sensor network. The design offers an association between the data acquisition function, the tracking and localization function, the communication function based on a DSP structure, and the radio modem. The performances of this device (low power consumption, reduced error bit rate, high computational capacities) are fair enough to recommend it for use as a node in a wireless sensor network.

When the node moves, we can consider some objects namely obstacles that can obstruct the node's driving path. The obstacle detection functionality is important even for the path following conception. For this reason, a complete data interpretation and a fusion by correlation between sensor data are necessary. The data fusion method consists in the association between a video-camera (to obtain a 2-D field image) and other sensors (laser, sonar or tactile) to evaluate the distance to various objects in the motion space.

One important class of WSN is wireless *ad hoc sensor networks* (WASN), characterized by an ad hoc or *random* sensor deployment in which the sensor location is not known *a priori*.

On the other hand, navigation techniques, that can derive localization, generally consist of three components:
a) Identification and data exchange,
b) Measurement and data acquisition, and
c) Computation to derive location. Measurements can be made of the distance or the angle based on an incoming signal.

The methods used include different solutions: hyperbolic trilateration, triangulation, multirateration.

Thus, the main paper scope is to present a system for identification, tracking, localization and data acquisition through mobile sensors networks. This is corresponding with the researches from the European level technological platforms (Embedded Systems, Mobile and Wireless Sensor Networks) based on incorporation of some high innovator concepts and recent technologies developed for automation, identification and data acquisition field (AIDC - Automatic Identification and Data Capture).

The rest of the paper is organized as follow. Section II describes the configuration of a sensor node based on a possible DSP implementation. Section III presents the procedure for mobile object tracking. Section IV discusses the modules for obstacle detection based on data fusion. Section V presents the modular implementation for IMN identification, localization, wireless communications, data acquisitions, and power supplying. Finally, a section of conclusion outlines the results of the research work, the advantages, limitations and possible applications.

II. Configuration Of A Sensor Node

An mobile sensor node (IMN) consists of several functional blocks as seen in Fig. 1: power, data acquisition and navigation, data processing, and communication. The specific requirements for a particular block can differ depending on the application:

▪ A large-area low-density sensor network deployment will require a more powerful radio than a short range indoor or sensor application.

▪ Applications where high data rates and complex signal processing functions are required will benefit from a more powerful signal processor.

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▪ Sensors and associated sensor electronics will vary from application to application.

▪ For some applications the power can be provided by an appropriate primary battery, whereas others call for a complete power management system that can scavenge energy from the environment.

Therefore, if the wireless sensor module architecture is to be suitable for a broad range of applications, it should be designed in a modular fashion. The blocks in Figure 1 was implemented as distinct hardware layers (modules) which can be plugged together like Lego blocks to obtain a sensor module with the desired functionality. Also, the corresponding software has a modular structure. The hardware-software resources must have an optimum representation. The data processing and control block can be reprogrammed in-system to provide this application-tailored functionality.

The target hardware architecture consists of sensors, power sources, SRAM memory, CPU core, general purpose I/O, RF communication unit and digital logic for the embedded operating system. We decide to prototype the architecture using DSP technology to implement the CPU core, digital logic and general purpose I/O. The digital logic of the DSP device can be used to interface to general purpose I/O, this will be necessary to connect sensors, actuators, memory and network interfaces to the CPU. It can also be used to implement custom hardware accelerated user-instructions for the CPU core. Processing that does not map well to the CPU instruction set, or whose computationally requirements make it difficult to meet real-time performance constraints are candidates for implementation in hardware logic. Nodes requiring digital signal processing of audio/video data may require such functionality. The ability to add new functions based on the DSP capacities is specific for the chosen architecture.

The IMN software architecture responds to the requirements of the software framework of the whole network. The components of the framework provide the functionality of single sensors, sensor nodes, and the whole sensor network. According to these components, applications are classified into *sensor applications*, *node applications* and *network applications*. The software implemented on IMN corresponds to the first and the second levels. A *sensor application* contains the readout of a sensor as well as the local storage of data. It has full access to the hardware and is able to access the operating system directly.

The sensor application provides essential basic functions of the local sensor node, which may be used by the node application. The *node application* contains all application specific tasks and functions of the middleware to build up and maintain the network e.g., routing, looking for nodes, discovering services, and self localization.

Primary objective of the middleware layer is to hide the complexity of the network environment by isolating the application from protocol handling, memory management, network functionality and parallelism.

A middleware for sensor networks has to be scalable, generic, adaptive and reflective. Resource constraints (memory, processing speed, band width) of available node hardware require an optimization of every node application. Thereby, the application is reduced to all essential components and data types and interfaces are customized (*scalable middleware*). The components of the middleware require a generic interface in order to minimize customization effort for other applications or nodes (*generic middleware)*.

The mobility of nodes and changes of infrastructure require adaptations of the middleware at runtime depending on the sensor network application. The middleware must be able to dynamically exchange and run components (*adaptive middleware*). Reflection covers the ability of a system to understand and influence itself. A reflective system is able to present its own behaviour. Thereby, two essential mechanisms are distinguished – the inspection and the adaptation of the own behaviour (*reflective middleware)*. In contrast to an adaptive middleware, a reflective middleware does not exchange components but changes their behavior. An example of reflective behavior is the modification of the routing strategy depending on mobility.

The software architecture of the system prototype integrates data acquisition, remote communication, identification, and localization functions in a modular structure that allows easy adaptability to the specific application requirements and has flexibility in developing and modifying the application software.

Localization function utilizes data from more nodes and more sensors from same node. The data are process and correlate interpreted through so called *data fusion*.

For *identification and tracking function* it is realized a much simpler device, like identification tag through radio frequency (RFIDT), which allow only localization at distance of some object dispersed on wide geographical area.

The program package for providing the communication in wireless sensor network, is designed by solving the problem of data package rooting, using IMN as relays, also in the case of mobile nodes.

Correlative processing of data from more sensors or more sensorial nodes, by fusion (data fusion), conducts to improvement of accuracy and precision (For example, positioning and navigation of mobile robots, using complementary and competitive data fusion from visual, ultrasonic and laser sensors [2]). For positioning function, the GPS utilization is unsatisfactory. From this reason, a great part of the research activity is dedicated to methods and algorithms which permit accurate localization of the mobile sensor network nodes, which have unpredictable motion inside a weak structured environment. The localization is made relatively to some fix nodes of the network, through data fusion from sensorial nodes. The network is independent, in the sense of its auto learning capacity and the functioning was simulated in virtual environment.

III. Procedure For Mobile Object Tracking

The sensors are used to collect information about mobile target position and to monitor their behavior pattern in sensor field. A mobile object tracking system is a complex mechanism that is accompanied with collaborative works between nodes. Tracking of the mobile targets has lots of open problems to be solved including target detection, localization, data gathering, and prediction.

In the localization problem, excessive sensors may join in detection and tracking for only a few targets. And, if all nodes have to always wake up to detect a mobile target, there are a lot of waste of resources such as battery power and channel utilization. Actually, power conservation is one of the most critical issues in object surveillance and tracking since the sensor nodes that are once deployed in the sensor field would be difficult to replace a battery.

Energy dissipation in sensors is various depending on condition of each sensor, for basic sensing operations, for powering the memory and CPU, and for communication between nodes or sink. So, if each node uses timely its energy to execute tasks, the network lifetime may be extended as a whole. Therefore, each sensor must minimize its battery power usage for desired longevity of network operation, which can be accomplished by properly managing sensor's operation.

When a target moves around far away from the sensing range of a certain node, the nods does not need to keep wake up for participating in tracking of the mobile target. This raises the necessity for prediction of the moving path of the mobile target to maintain the number of participating nodes in tracking as small as possible [15], [16].

In general, the target localization is estimated successively based on the predicting of the next location, which is a result of the current measurement at a sensor and the past history at other sensors. The goal of this paper is to propose an efficient tracking method that can minimize the number of participating nodes in mobile target tracking to extend the network lifetime.

Our sensor can operate under the three different conditions: Active, Idle and Sleep. It is important to completely shut down the radio rather than put it in the idle mode when it needs not sensing. Power management of sensor components is very important because energy consumption is depends on their duties. To save energy resource and thus extend the network lifetime, it is desirable that only the nodes that surround the mobile target are responsible for observing the target (Fig. 2).

Instead, it is more energy efficient for only the nodes *S* around the mobile object to join in collecting information of the target and performing collaborative work among them. Other nodes located far from the target do not need to waste their powers to monitor the target. If we can predict the next location of the mobile object in advance, we can organize the group membership dynamically which should join in tracking mission. The number of participating nodes may be minimized, which allows us to further extend the whole network lifetime if we predict future location of the mobile target accurately.

As the mobile object moves, the tracking nodes may migrate to the moving direction of the target to keep on monitoring as shown in Fig.2, where a thick line indicates the moving path of the mobile target and the blacked circles inside the dotted circle are tracking nodes at time t_1. Thus, sensor nodes need to control their states by themselves based on prediction of target's movement.

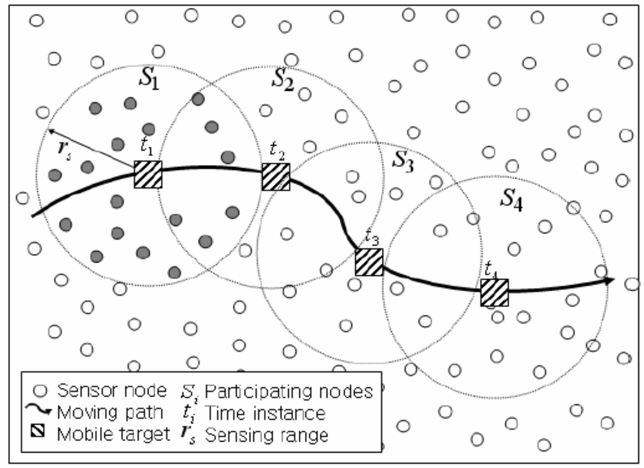

Fig.2 A concept of tracking of a mobile object

We assume a sensor network where *N* sensors with a different communication and sensing range are distributed randomly in the environment that is being monitored. We also assume that each node knows its own location by using GPS or other location awareness techniques. We utilize triangulation for localization of a mobile target. Consequently, at least three sensors join the target detection and tracking with surveillance. Also each node keeps information about its neighbors such as location through the periodically message change and each individual sensor node is equipped with appropriate sensory devices to be able to recognize the target as well as to estimate its distance based on the sensed data. Further, we assume that we predict the location of the mobile targets every one minute and each sensor records the movement pattern of the mobile object.

Basically, we use a *moving average estimator* to predict the future location of the mobile target based on the measurement of direction and the velocity of the mobile target. Therefore tracking in our system is performed by the following procedure:

1. Discovery: When a sensor node around the mobile object detects the target and initializes tracking, it becomes 'estimation node' which acts as a master node temporarily.

2. Localization: A set of nodes those become aware the appearances of the mobile target compute the target's current position. The coordinates of the mobile target may be accomplished by the triangulation and their collaborative works.

3. Estimation: An estimation node predicts the future movement path of the mobile target, and transmits message about the approaching location to its neighbor nodes. The prediction is carried out by two steps: approximate a prediction and correction step. The moving factors of a mobile target, such as direction and velocity, can be obtained by sensor nodes through collecting moving patterns of the tracked target.

4. Communication: As the mobile target moves, each node may hand off an initial estimate of the target location to the

next node in turn. At that time, each node changes its duty cycle along the movement of the target.

IV. MODULE FOR OBSTACLE LOCALIZATION

Sensing the environment, IMN can navigate in order to find objects and to examine the environment. It is necessary to integrate several different sensors on the robot, as every sensor has its own advantages or disadvantages. The processing goal is the data fusion.

A. *Ultrasonic sensors*

Ultrasound sensors are used mainly in obstacle detection and for distance detection up to the work area border or the environmental objects. The system was designed to read data from a certain number of sensors.

The module has three main components: multiplexer, amplifier system and tone decoder (Figure 3). The multiplexer commutes the four channels of the ultrasonic sensor module. The amplification module increases the received signal amplitude, which is detected after that, by the tone decoder, which signals this issue on the out pin. Time measurement is done with the help of the microcontroller.

Reflected signal amplification must be done according to the sensor usage domain. For small distances up to 30cm a small gain is recommended, because the sound attenuation in air is reduced. For large distances a more powerful gain is required to compensate for the sound attenuation. For distances over 10cm, errors of 1-2% were obtained.

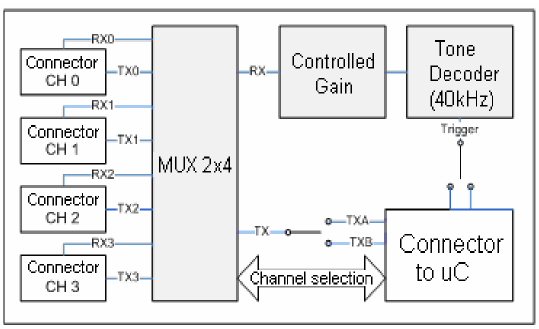

Fig. 3 Ultrasonic module

B. *Color sensors*

The color sensor is used for color determination of the work objects. It is mounted inside the robot to assure same illumination conditions at each measurement.

The used color sensor, TCS230, is a light-frequency converter. The output is a rectangular signal with frequency proportional with the light intensity. The out frequency can be scaled in three ways through three control pins.

The three color intensities R, G, B are being read and the light intensity without filter. Then the relative colors are calculated (the three measured colors intensity is divided at the white light measured intensity) after which, based on some experimentally determined thresholds, the color is decided.

Reading the sensor is reduced at reading a frequency. First detected front is omitted, and more periods are counted for a higher precision. To avoid large errors, environment illumination has to be matched between certain limits.

C. *Infrared sensors*

Infrared distance sensors are used for work objects detection which enters the gripper work range. This type of sensor is used (GP2D120) because it offers a higher precision on very small distances. The sensor provides with an analogical voltage which is adequate to the distance. Because of the non-linear characteristic, the use of a voltage-distance correspondence table was required. Also, because the characteristic has a local maximum, correlation of the read values with the known functioning domain of the sensor was required.

D. *Accelerometers and incremental encoders*

Accelerometers are inertial sensors and are being used today in various applications. They can be used to obtain data about a mobile traveling on more axes, but data processing is required. To obtain the distance, acceleration needs to be integrated twice:

$$\vec{s} = \int\left(\int(\vec{a})dt\right)dt$$

Numerically, the estimated calculation formula of the integral between two samples is the following:

$$Area_n = \frac{Sample_{n+1} + Sample_n}{2} \cdot T$$

where T is the sampling period.

The upper formula has to be applied twice, firstly to obtain acceleration speed and secondly to obtain motion based on speed. Therefore we will have the following iterative relations:

$$vit_{n+1} = vit_n + \frac{acc_{n+1} + acc_n}{2} \cdot T$$
$$dist_{n+1} = dist_n + \frac{vit_{n+1} + vit_n}{2} \cdot T$$

Accelerometers are used generally in combination with other sensors, since they are strongly affected by errors.

In our application we used accelerometers together with position encoders on the motors, based on the complementary fusion and the competitive one.

Though very precise (Figure 4), the great disadvantage of encoders is the fact that they can offer motion data only on a single coordinate, the motion direction. Therefore the direction drift, caused by some perturbations, can not be seized with the help of the encoders.

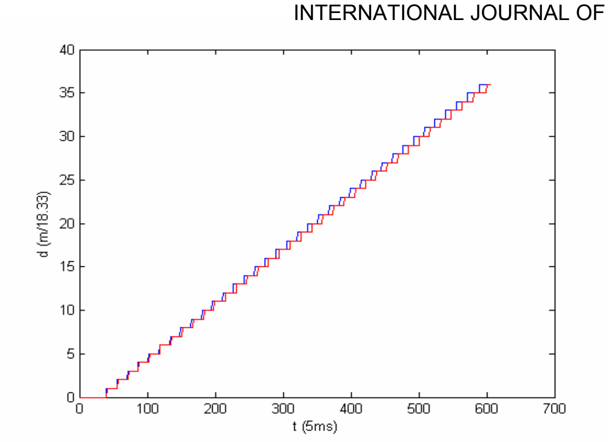

Fig. 4 Distance measured with encoder

The accelerometers, though not so precise (Figure 5), can offer motion data on three coordinate axes. Because the movement is made on plan, we are interested on the motions on two coordinate axes only.

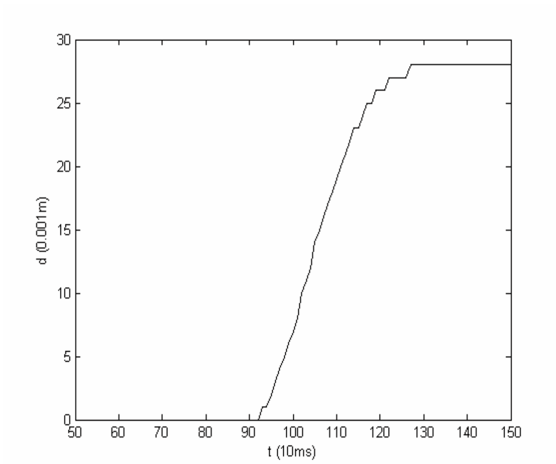

Fig.5 Distance measured with accelerometer

The trajectory diverts cannot be sensed by the encoders, but can be sensed with the help of the accelerometers, through measuring a motion on a perpendicular direction on the mobile robot motion direction. These observations are not useful to correct dynamically the robot motion, but can be used to correct the final position of the robot through adding the motions sensed by the accelerometer on other directions than the movement one. Therefore a movement error lowering can be obtained and an improvement of the robot positioning.

In case of the translation moves using only odometry a robot drift up to 4 cm to right has been noticed, on a 1 m displacement. It doesn't look much, but such a drift could keep us from reaching our goals. With the help of the accelerometers this drift is sensed and can be corrected with a 1 cm error. So the final position of the robot, recorded by the microcontroller, will be close to its real position, after a translation.

In case of the rotation movements the accelerometers can not be used, resulted data being incorrect.

E. Video camera

For the artificial view an NXTCam made by Mindsensors has been used. The camera has a signal processor integrated that handles the video processing. The capture is made at a resolution of 88x144 pixels and 30 frames per second. Interfacing with the rest of the system is done through an I2C interface. Also camera disposes of an USB port through which the connection with the PC is realized.

The data fusion method usually consists in the association between a video-camera (to obtain a 2-D field image) and other sensors, less sophisticated, to evaluate the distance to various objects in the motion space. The associated sensors can be of different types: laser, sonar or tactile. The advantages of data fusion sensors are the following: possibility of detecting any obstacles (small or big) without constraints about position, color or shape; the accuracy independence from the image texture and contrast; a drawing in the amount of processed data; high angular and depth resolution, relatively low cost and high speed data acquisition.

The information from sensors are use either locally by the module direct connected to sensors, as in the case of color sensor, and IR one from the clamping system, or either used through fusion by other modules as in case of ultrasounds.

The communication is made through the CAN Bus protocol over RS 485 electrical standard. The interconnection bus allows transparent ways of communication for the programmer, such as *automatic replay*, witch is used for total decoupling between the proper distance reader algorithm and the main control algorithm.

The camera is situated in the front of the robot, centrally. In case of an object enters in the visual range, the robot perform a compose rotation until the object is centered in the image. The rotation is carrying out step by step with a known angle and thus the new orientation is computed. After the object is placed on the robot trajectory, the robot will start the motion to the target. If the object is not detected by the sensor on the gripper after a distance of 40 cm, the robot will continue its initial route to the destination.

In the basic design, the mobile sensor node has the following sensors for environment interactions: infrared proximity sensors, Ultra Sonic Sensors, a Video Camera and a Differential Global Positioning System (DGPS) device to determine IMN location in a specified area.

For short-range sensing and simple navigation tasks, two IR sensors are placed around the robot's chassis in a height of 35mm. Short pulses are emitted cyclic around the robot and received by the IR sensors. The analogue sensor signals are processed by a DSP soldered on the inner side of the wheel house and can be requested via the I2C link.

For more detailed environment sensing, a video camera system is integrated into the platform. The integrated image device incorporates a CMOS sensor with VGA resolution, on-chip image processor and JPEG codec for optional image compression.

For obstacle localization and navigation, we utilize a dual system based on sensor data fusion. The sonar detects the well defined objects with high confidence but the angular resolution is low. From this point of view it is necessary a complementary sensor (CCD camera). The dual sensor system must be assisted by a knowledge-based system using a dynamic data base with rapid access and a dedicated hardware structure for rapid data processing. In order to explore the space in the close neighborhood of the mobile object (assimilated with a mobile WSN node), a priority window is selected from the complete field. Every object which appears in the priority field – for example, Ob_1 in Fig. 6 – is considered as a virtual obstacle. The notation significances are the following: PW – priority window; Ob– obstacle; M – lane marks, A – the nearest point of an obstacle; O – the origin of the priority window and also of the image field; α_1 - vector radius angle.

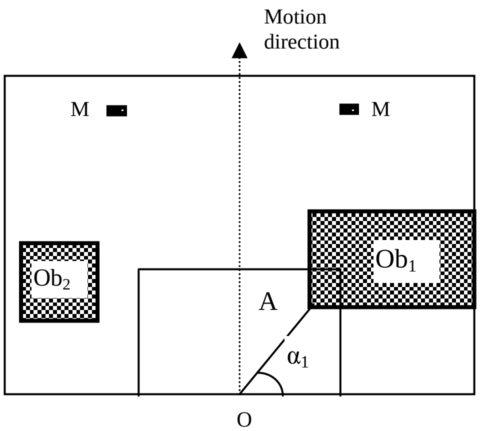

Fig.6 Moving objective path configuration

In Fig.7 it is presented the block diagram of the system build around a central processing unit. The block significances are as follows: C – CCD camera, obliquely oriented with respect to the motion plane; O – object (obstacle) in the motion space; IA1 – image acquisition block for a priority window; IA2 – image acquisition block for the complete field; PP1 – primary processing block of the image corresponding to the priority window; PP2 – primary processing block of the image corresponding to the complete field; SS – multi-sonar configuration; DM – distance measurement block; SC – sonar control block; MPU – main processing unit.

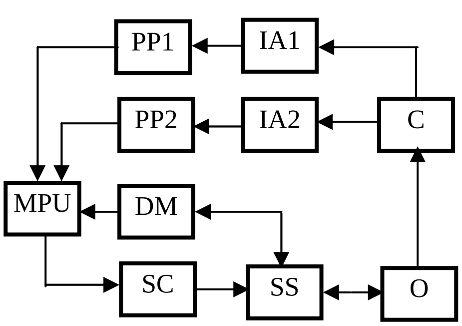

Fig.7 Block diagram of the data sensor fusion based system for object detection

The architecture presented in Fig.4 offers the possibility to perform a fast parallel primary processing at the level of the hard units PP1, PP2, DM, which diminishes the computing time and discharges the main processing unit from these costly processing tasks. The main processing unit ensures the sensor data fusion and processing of sensor information already refined as above mentioned by using dedicated operational tasks under the coordination of a supervising module.

V. Modular Implementation For An Intelligent Mobile Node

There are four main hardware modules incorporated in the IMN structure: the communication module, the video module the data acquisition module (sensors module), and the power module (Fig.8). Each unit is single board implemented around a dedicated chip.

The description of each level with its technical features and the motivation for its components selection are presented in the following.

- *Communication module*

The module, which has the size of a matchbox (Fig.9), communicates with the WLAN router at 54 or 11 Mbit/s (802.11 g+b) found on the NMN. Both stacks for TCP/IP and/or UDP are integrated as well as the server for HTTP which can be used for friendly user access to node parameters through web interface. Because the module is programmable using BASIC, specific applications can be integrated quickly and simply. In addition, software interfaces are available for Windows CE and Linux. Also it provides security and integrity of data (WEP, WPA (TKIP) and WPA2 (AES) encryption, TCP/IP for data integrity) at data rates up to 5MBps.

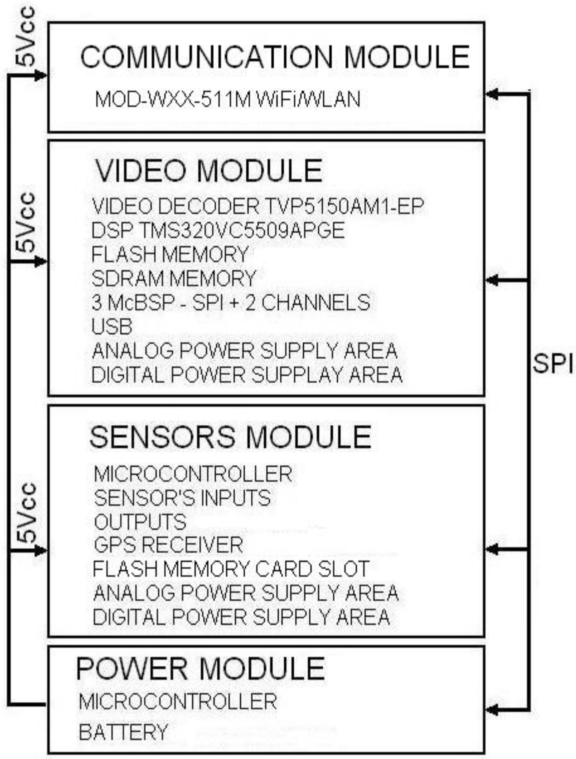

Fig.8 Modular implementation of an intelligent mobile node

The previous presented feature and the SPI interface availability which we used as the main "bus" between the modules of the IMN, recommend it as a good solution for the communication module.

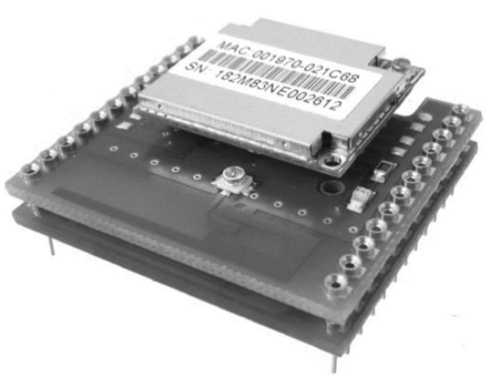

Fig.9 The communication module

- *Video module*

The components of the video module are presented in Fig.10.

The video module supplies the support for the platform video interface, and for the low level digital image processing.

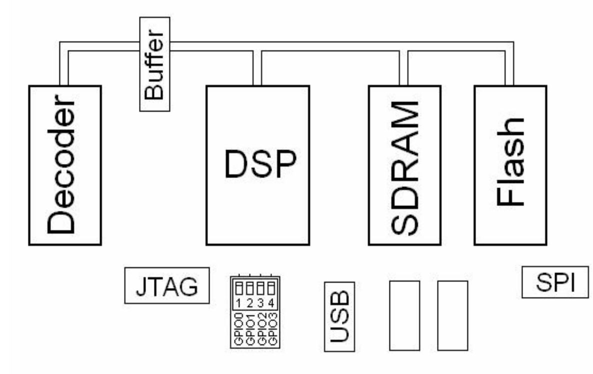

Fig.10 The components of the video module

Video module is connected with the other modules of the platform by means of Serial Peripheral Interface (SPI).

The video module is accomplished around a Digital Signal Processor (DSP) TMS320VC5509A, 200 MHz. It contains the following components and characteristics:

-video interface with TVP5150AMI-EP;

-32Mx16 bits extern SDRAM (4 pages with 8Mx16 bits each);

-512Kx16 bits extern Flash (32 pages with 16Kx16 bits each);

-128Kx16 bits RAM in DSP;

-32Kx16 bits ROM in DSP;

-2 Timers, 20 bits;

-Watchdog Timer;

-DMA 6 channels;

-SPI Interface by configuring one channel of McBSP (Multi-channel Buffered Serial Port);

-2 McBSP channels;

- USB Full-Speed (12 Mbps);

- Real Time Clock;

-2 analogue inputs and ADC, 10 bits.

- *Sensor module*

This module has as central processing unit a mixed signal processor from Texas Instruments, MSP430F5438. This microcontroller with three 16-bit timers, a high performance 12-bit analog-to-digital (A/D) converter (16-Channals at 200ksps), 4 universal serial communication interfaces (USCI), hardware multiplier, DMA, real time clock module with alarm capabilities, 87 I/O pins and in association with the ultra-low power consumption (Active Mode (AM): 165 mA/MHz at 8 MHz, Standby Mode (LPM3 RTC Mode): 2.60 mA, Off Mode (LPM4 RAM Retention): 1.69 mA, Shutdown Mode (LPM5): 0.1 mA) is a very good match for the sensor module. A powerful feature of this chip it is his Flexible Power Management System which is in tone with the entire project requirements and goals. The module is also equipped with a SD memory slot (with a SD card with custom capacity) where it is stored a log of data and "transaction" (commands, decisions, etc), used in case of poor transmission data rates.

- *Power module*

It is developed around Texas Instruments microcontroller MSP430F149. The architecture, combined with five low power modes is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that attribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 6 μs. The 60KB+256B Flash Memory and 2KB RAM offer the possibility of implementing code with boot-loading ability for future optimization of code and facility of downloading the new code remotely through the communication module via SPI interface. The microcontroller has a 12-Bit A/D converter with internal reference, sample-and-hold and autoscan feature which is used for battery energy level monitoring. Another feature for this choice was the power consumption of the microcontroller: − Active Mode: 280 μA at 1 MHz, 2.2V − Standby Mode: 1.6 μA − Off Mode (RAM Retention): 0.1 μA.

This module is designed to manage the power consumption of the entire node, and if the buttery level become critical or the application requests the module can turn off the supply of the other modules or put them in another state of functioning (stand by, idle, etc).

VI. Conclusion

The design of radio networks of mobile sensors and their implementation is a modern topic; nowadays developed countries invest a lot of resources to diversify and develop the specific infrastructure and services. The device proposed in this paper is part of a highly performing communication equipment that aims to combine message processing procedures with signal processing procedures and multi-point transmission organization, which today offers the best performance/price ratio for solutions for information remote transmission based on wireless channels lead to the use of combined techniques of multipoint transmission processing and organization. We have motivated and presented the design of a new architecture for the nodes of a sensor network. The architecture differs from previous work in being based explicitly on a hardware/software co-design approach in order to improve optimization and adaptability. Because an important objective was the simplification of development of service applications for wireless sensor networks, a key issue was to separate the software from underlying hardware and to divide it into functional blocks. The presented software architecture and design flow facilitates the programming on high abstraction layers. Reducing energy consumption was the aim of other new proposed procedure, representing an efficient tracking method using a moving average estimator to decide the future location of the mobile target. Simulations results show that our estimation method performs accurately, which contributes to saving energy and thus extending the network lifetime as well regardless of mobility pattern of the mobile target by reducing the number of participating nodes in tracking.

Our current research activities concentrate on the realization of the proposed architecture embedded in a framework. It simplifies the development of single sensor, node and sensor network applications. Besides that, it provides functionalities to configure and manage the whole network, whereby the scalability and portability of applications increases. Our immediate research challenges are to determine appropriate abstractions for the construction and deployment of the embedded systems architecture from hardware and software perspectives. We intend to evaluate our work against a range of applications, both to check the qualities of the implemented solution for IMN and to derive methodological understanding that aids the creation of complex sensor networks. The simulations were made in virtual and real environment. Also, it was realized a physical model, at reduced scale, with four mobile platforms, independents, each endowed with one minimal sensor network node. Validation in virtual and real environment allowed the implementation of a prototype, able to be configured upon request, by the economic unit. Thus, the prototype was configured and experimented for two applications: a mobile robot network and a network of mobile objects for quality and safety of the environment.

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