Electric Scaled Vehicle as ITS Experimentation Platform

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Abstract. Intelligent Vehicle Robotics is a research area affordable only to big size research groups, mainly because of its high costs. By the present work we propose to develop Intelligent Vehicle Robotics research with modest budgets using an accurately scaled platform.

We have developed a scaled intelligent vehicle model to simulate private electric vehicles. It is a low cost, flexible, expandable and open platform that has been meant to test intelligent vehicle solutions to be, after that tested in real scale intelligent vehicles. We have called the model ASEIMOV, standing for Autonomous Scaled Electric Intelligent MOnitored Vehicle.

The model consists of a scaled electric vehicle that has been equipped with sensors, web cameras, a PC computer, batteries and ballasts to simulate physically and through software an electric smart vehicle. A carefully scaled vehicle means that the successful solutions tested on the scaled platform are worthy to be tried on real scale smart vehicles in a further step of research. Through this work we describe the ASEIMOV model.

1 Introduction

Intelligent vehicles have being announced as the next revolution on mobility aiming to safer and more efficient transports. There are some "intelligent" solutions already in the streets, but much more are to come. They will cover a wide range from safety applications to unmanned navigation systems, including collision avoidance (e.g. [11]), Lane Detection and Following (e.g. [14]), following a leader (e.g. [10]), overtaking aid systems (e.g. [13]), etc.

To build a prototype, as a tool for testing new intelligent vehicle solutions may be really expensive and within reach for a small list of research centers.

We have designed a new model of research platform to simulate private electric vehicles. The aim is to have a low cost, easily implementable experimentation device that permits researchers to test intelligent vehicle solutions.

By this work, our purpose is to present a scaled intelligent vehicle model that could be built by a wider set of researchers to test intelligent vehicle solutions that could be then experimented in full scale intelligent vehicles.

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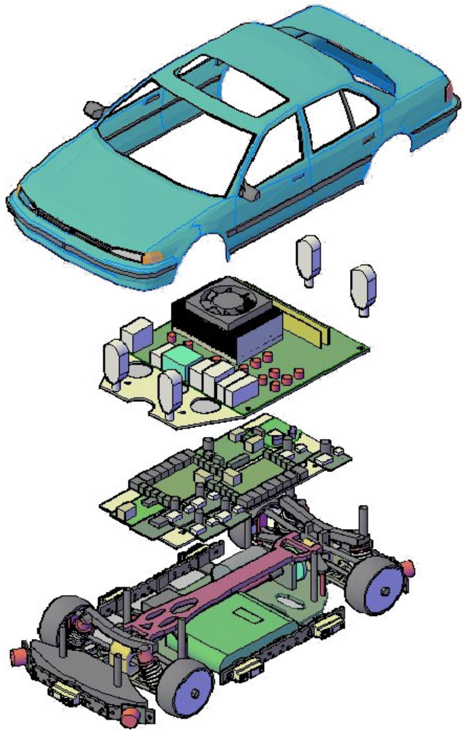

Fig. 1. ASEIMOV 3D Model

To carry out this, the proposed model needs to be as accurately scaled as possible. Its dynamic behavior – e.g. acceleration and braking curves – should be very similar to the full size intelligent vehicle where the obtained solutions, algorithms, etc., are planned to be validated.

The model consists of a scaled electric vehicle that has been equipped with sensors, web cameras, a PC computer, batteries and ballasts to simulate physically and through software an electric smart vehicle. A fine scaled vehicle makes the successful solutions tested on it good candidates to be tried on real scale smart vehicles in a further step of research.

It puts together some interesting paradigms like:

- Low Cost (but not Low Quality) Research: As a small group researching on Intelligent Transportation Systems we are aware about the importance of cheap technologies to be attainable by a bigger amount of researchers and groups from all around the world.
- Free Software: In our group we are firmly convinced about the idea of Academic Researchers should use free software for the sake of researcher independence and fair productivity feedback to global society.
- "Off-the-shelf" computer components: In the same line as above, this kind of components may be cheaper and easily obtained by researchers anywhere.

Fig. 2. First ASEIMOV Unit

Besides that, this kind of architecture has some very interesting features:

- The developed model is flexible, reusable and expandable, mainly thanks to the PC computer and PC-compatible robotic components installed.
- We used a 1/10 scale Remote Control car as a basis for the chassis – See 2.1.
- We scale a real size acceleration and braking functions (using software over the on-board PC) and its mass distribution (using ballasts)– see setion 2.6.
- We have implemented the concept of Safety Bubble using PC-compatible robotic sensors – See section 2.4.
- We have even developed a speed probe using a recycled ball mouse and the PS-2 port at the computer. With this sensor in combination with a robotic accelerometer we will face the odometry[1] of the vehicle – See 2.5.

1.1 State of the Art

There are many groups working on intelligent prototypes all around the world. Some remarkable approaches are: GRULL *Grupo de Robótica de la Universidad de La Laguna* with the project GUISTUB *Guiado de un Sistema de Transporte en una Urbanizacin Bioclimtica Cerrada*. They have designed a vehicle called Verdino [9], [6], [8].

Another remarkable research is the one from VISLAB. They are a spin-off company of the University of Parma; which is involved in basic and applied research, developing machine vision algorithms and intelligent systems for different applications, primarily for the the automotive field. They have performed several autonomous real prototypes since 1994 – e.g. [7], [5].

Other interesting research project is the so called AUTOPIA from CSIC, Madrid [12]. They have taken technology developed for mobile robots to the automotive world. They have also developed several prototypes of fuel and electric vehicles. Stanford University stands out in this area with the vehicle Stanley [1].

[1] Odometry: Estimation of the position and speed of a moving object.

Finally, the Japanese company ZMP.inc. [2], [3] has a very interesting scaled vehicle called Robocar Z. It is a small robotic vehicle to test autonomous navigation algorithms.

2 Model Description

In figure**??** it is shown a 3D modeled ASEIMOV prototipe decomposed into its main components. In that figure can be observed from top to down, the Mini ITX computer in the top of the available space withing the vehicle. Down there there is a second platform where most of the robotic component card are placed – DC motor controller, servomotor controller, accelerometer, and sonar and infrared sensor acquisition cards. Finally, in the botton we can see all the mechanical components, the batery, webcams, and all the sensors around the custom-made supporting structure.

Every unit needs to satisfy three strong restrictions: Scarce space available, low budget and an acceptable autonomy for lab tests. Across the rest of this section we will explain the more relevant parts of the ASEIMOV model.

2.1 Chassis

In this section we will explain the main structure that supports all the elements in every ASEIMOV unit: The chassis. We need as much free volume as possible.

We realized that a good option may be to use a commercial RC vehicle as a starting point because of several reasons: RC vehicle's chassis bears a strong resemblance to a real size vehicle mechanical elements. On the other hand, this vehicle has a flat internal structure, this gives us the possibility of a free and comfortable internal space to allocate the PC and all the electronic elements needed to build an ASEIMOV unit.

For the first ASEIMOV unit we have used a Kyosho TF-5 RC electric car (1:10 scale). As can be observed in figure 1, we have designed a two shelf structure using methacrylate to hold all the electronics devices and the PC motherboard.

2.2 Locomotion

Typically, the locomotion of a vehicle requires controlling two things: traction and steering. In our model, two electric engines are used. A DC engine is used to the traction, and a servomotor is used to control the steering. Both motors are electronically controlled by the on-board computer.

To control the traction motor we have used the LV PhidgetMotorControl DC motor controller, which is connected to the on-board PC using a USB connection.

As for the steering movements we have used the servomotor included in the brand new Kyosho car that allows the right and left turn of the front wheels. That servomotor needs to be controlled by another circuit. In our case, we have used the one provided also by Phidget – PhidgetServo 1-Motor– again, connected through an USB cable to the PC motherboard.

2.3 PC Platform

A key element of the ASEIMOV model is the on-board computer. We have designed this model as a flexible research platform where different equipments can be installed depending on the specific configuration needed for every test. That is why we have included a complete PC with a Linux distribution, aiming to flexibility.

Communication. An interesting topic is the communication between our car and a remote computer. Once this communication is ensured by the constraints of speed in communication from our pc could drive the vehicle. With communication we try to touch as little as possible to ASEIMOV.

The overall control system can be administered through a Secure SHell server – OpenSSH in this case – located in the computer system of ASEIMOV.

2.4 Safety Bubble Detection

The vehicle must know what is around. Because of this, the car must be equipped in order to implement a safety bubble. This could help the implementation of intelligent algorithms ensuring a safe distance from any near obstacle or vehicle.

For the first built unit, we have installed 8 short range (10 to 80cm) IR distance sensors, a front wider range (20 to 120cm) IR distance sensor, and 7 sonars sensor (with a usable range from 0 up to 645cm) around the vehicle. All these sensors are connected to two Phidget 8/8/8 boards which are connected to the on-board PC by USB.

Fig. 3. Sensors in the Front of the Unit. From Left to Right, Top to Down, Short Range IR Sensor, Sonar Sensor, Medium Range IR and Short Range IR.

The sensors used may be easily substituted by other PC compatible ones. For instance, laser sensors may be used to get more reliable distance measures if the solution under study demands it.

2.5 Vehicle Positioning

Many vehicular robotic applications needs of tracking the vehicle position. In real scale vehicles this task use to be solved by means of GPS or similar technology.

In our case, we have included two electronic devices within the prototype we presume that could help us determining its relative position: a three axes acceleration sensor, and a home-made speed encoder.

2.6 Mass Scaling and Speed Scaling

We need our platform to be as close as possible to real size cars regarding its dynamic behavior. This is a key hypothesis of our model, since we want the successful intelligent vehicle applications developed over the ASEIMOV prototype to be then extrapolated to real size cars.

The strategy devised to get that goal is two folded:

1. First we make our prototypes to have a mass balance equivalent to the mass balance of the real size car taken as a reference.

   The dynamic response of the vehicle is directly proportional to its mass [4]. For the present work we have modeled a rough real size electric vehicle taking commercial electric vehicles currently or soon in the streets as examples – see 12. Using SolidWorks, we have calculated its center of mass. Then we calculate for that modeled real size car the mass balance between the right and the left side, and between the front and the rear of the unit. We do the same for the scaled ASEIMOV unit.
2. Second, every ASEIMOV unit needs to incorporate a closed-loop adaptive control system that adjust its longitudinal speed within a bounded range consistent with the acceleration and braking curves scaled from the real simulated car.

3 Control Application Developed

In figure 4 it is shown the control application developed for the ASEIMOV units – called JASEIMOV. This software is under GNU Public License and can be downloaded from *http://cicei.ulpgc.es/aseimov/*.

Basically, it is a user-friendly intuitive Java application using a server-client scheme where every ASEIMOV unit can be remotely controlled, and every sensor can be sampled in real time. In every ASEIMOV unit server process needs to be run and in any other PC connected to the same Wi-Fi network a JASEIMOV client can be run.

4 Conclusions and Future Research Plans

In this paper we have presented a new model of experimentation platform on intelligent vehicles, we have called ASEIMOV, standing for Autonomous Scaled Electric Intelligent MOnitored Vehicle.

The main hypothesis of the presented model is that is is possible to develop a scaled intelligent vehicle to test vehicular robotic solutions without the high costs and difficulties of real size experiments, and afterwards to extrapolate the more interesting to real size intelligent vehicles for further tests.

To achieve this goal we need the scaling process to be as accurate as possible. In the first ASEIMOV built unit we have approached that accuracy by two means: simulating the mass balance and the dynamic response of a real size vehicle, first by introducing small ballast in the platform, and second by an adaptive

Fig. 4. Control Application

Fig. 5. Calibration Setup

closed-loop control software which restricts the longitudinal speed within scaled real size acceleration/braking curves.

The presented model is a low cost model that can be assumed by researching groups without huge budgets available. This would increase the number of researchers in the area, with the obvious benefits that it would bring.

Besides that, the proposed model is such a flexible one since all the components are controlled by a Linux/PC. So, it can be custom-made built for many different applications incorporating other sensors, devices, etc.

About future work plans, there is plenty of work to do now. We need to accurately define the safety bubble we can use, with the current setup of sensors. We need to fully study the vehicle positioning by the combination of the homemade speed encoder and the accelerometer, or any other technologies available. We need to test the longitudinal speed adaptive control software with real acceleration and braking curves and see how it works. We also need to improve the control application, to get more capacities from it.

After that, we will be in a position to start exploring intelligent vehicle applications. Particularly, we have keen interest in building a cluster of ASEIMOV units and developing cooperative intelligent solutions.

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References

1. Stanford Racing Team, http://cs.stanford.edu/group/roadrunner
2. Website from ZMP.inc., http://www.zmp.co.jp/e_html/products_rc-z_en.html
3. Website about Linux, http://www.linuxfordevices.com/c/a/News/Linux-robot-car-targets-autonomous-navigation/
4. Fundamentos de mecanismos y mquinas para ingenieros (1998)
5. Automatic Vehicle Guidance: the Experience of the ARGO Autonomous Vehicle. World Scientific Co. Publisher, Singapore (1999)
6. Arnay, R., Acosta, L., Sigut, M., Toledo, J.T.: Detection of Non-structured Roads Using Visible and Infrared Images and an Ant Colony Optimization Algorithm. In: Krasnogor, N., Melián-Batista, M.B., Pérez, J.A.M., Moreno-Vega, J.M., Pelta, D.A. (eds.) NICSO 2008. Studies in Computational Intelligence, vol. 236, pp. 37–47. Springer, Heidelberg (2009)
7. Broggi, A., Bertozzi, M., Fascioli, A.: Argo and the millemiglia in automatico tour. IEEE Intelligent Systems 14(1), 55–64 (1999)
8. González, E.J., Acosta, L., Hamilton, A., Felipe, J., Sigut, M., Toledo, J., Arnay, R.: Towards a multiagent approach for the VERDINO prototype. In: Omatu, S., Rocha, M.P., Bravo, J., Fernández, F., Corchado, E., Bustillo, A., Corchado, J.M. (eds.) IWANN 2009. LNCS, vol. 5518, pp. 21–24. Springer, Heidelberg (2009)
9. Gonzlez, E., Acosta, L., Hamilton, A., Felipe, J., Sigut, M., Toledo, J., Arnay, R.: Towards a Multiagent Approach for the VERDINO Prototype. In: Distributed Computing, Artificial Intelligence, Bioinformatics, Soft Computing, and Ambient Assisted Living, June 10-12 (2009)
10. Lim, H., Kang, Y., Kim, J., Kim, C.: Formation control of leader following unmanned ground vehicles using nonlinear model predictive control. In: IEEE/ASME International Conference on Advanced Intelligent Mechatronics, AIM 2009, pp. 945–950 (July 2009)
11. Llorca, D., Sotelo, M., Parra, I., Naranjo, J., Gavilan, M., Alvarez, S.: An experimental study on pitch compensation in pedestrian-protection systems for collision avoidance and mitigation. IEEE Transactions on Intelligent Transportation Systems 10(3), 469–474 (2009)
12. Perez, J., Gonzalez, C., Milanes, V., Onieva, E., Godoy, J., de Pedro, T.: Modularity, adaptability and evolution in the autopia architecture for control of autonomous vehicles. In: IEEE International Conference on Mechatronics (2009)
13. Wang, F., Yang, M., Yang, R.: Conflict-probability-estimation-based overtaking for intelligent vehicles. IEEE Transactions on Intelligent Transportation Systems 10(2), 366–370 (2009)
14. Zhou, S., Jiang, Y., Xi, J., Gong, J., Xiong, G., Chen, H.: A novel lane detection based on geometrical model and gabor filter. In: 2010 IEEE Intelligent Vehicles Symposium (IV), pp. 59–64 (2010)