11th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.

ARCHITECTURE OF MOBILE ROBOT

Juraj Uríček, Viera Poppeová, Róbert Zahoranský, Ján Kuciak
Department of Machining and Automation
Faculty of Mechanical Engineering
University of Žilina
010 26 Žilina, Slovakia

Peter Šindler
Faculty of Electrical Engineering
University of Žilina
010 26 Žilina, Slovakia

ABSTRACT
This paper is oriented on development of flywheels mobile robots. There are described three construction applications of undercarriage for mobile robot and possibilities of their practical use. The first version is three-flywheel frame with differential control. In the second version mobile undercarriage is hanging up on the board. The third version has four-flywheel mobile undercarriage with more degree of freedom. There were developed also mobile robot moving control, driving system and gearing mechanism.
Keywords: *mobile robot, undercarriage, moving control, driving system, gearing mechanism*

1. INTRODUCTION
Industrial robots and manipulators, along with the NC and CNC manufacturing machines, automated transport, warehouses and pre-production stage automation systems, i.e. CAD/CAM (Computer Aided Design/Computer Aided Manufacturing), brought a new quality to the manufacturing system assemblies and became the foundation of flexible automated manufacturing and assembly lines and, consequently, an essential component of the most up-to-date CIM (Computer Integrated Manufacturing) manufacturing systems.
As opposed to most stationary robots, non-stationary robots are generally equipped with an undercarriage allowing the robot to move in various directions and at varying speeds – to so–called **mobile robot**.
Every mobile robot is usually original, it is sui generis. A multiple configurations of mobile robots are producing at the universities all over the world and they are using on training. Only a few of them are using on practical applications. They are caused by cheap labour or high purchase of control systems and first of all expensive sensors.
Mobile robots are usually divided by two main groups – for indoor and outdoor applications.
- **Mobile robots for indoor applications** are assigned on movement inside the factory buildings, rooms, basins and piping, where are not a big barrier (max. 5 cm).
- **Mobile robots for outdoor applications** are assigned on movement on broken ground (e.g. field, forest etc.), on repression of level and depth barrier.
  Outdoor mobile robots are more massive then indoor robots and they have higher performance, more complicated navigation system and other way of power supply.

Other dividing of mobile robots:
- **Biological systems -** they are going out from history, when a men started to imitate nature:
  - walking systems,

- sneaking systems,
  - climbing systems,
  - flying systems,
  - swimming systems.
- **Non-biological (artificial) systems** are systems based on discovered of handle and after-development in the form of roller and wheel:
  - flywheels systems,
  - bend systems

2. FLYWHEELS MOBILE ROBOTS

This type of mobile robot is using classic wheel, as actuator mechanism. At the present time are known one, two, three, four or more flywheels mobile robots. They are consisting of two subsystems:

- moving subsystem,
- navigation subsystem.

The base problem of design of mobile robot is specification and set-up of moving and driving wheels.

Two and three flywheels mobile robots

To this group we could allocate wide range of mobile robots, which are divided according of control style:

a) Ackerman control,
b) synchronous control,
c) robots with more degree of freedom,
d) differential control.

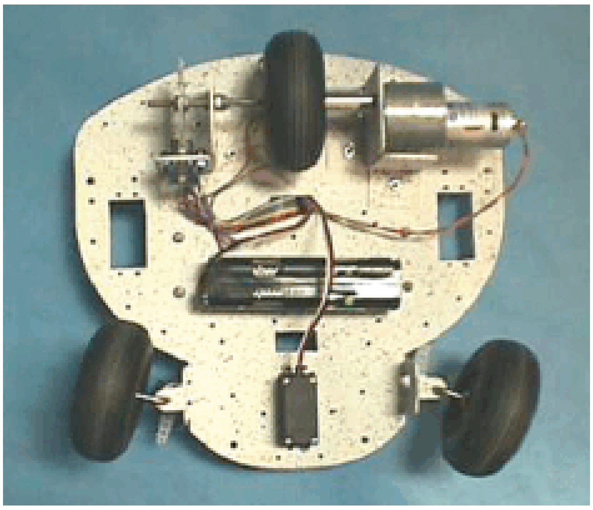

Figure 1. Tree-wheels undercarriage (firm Arrick Robotics)

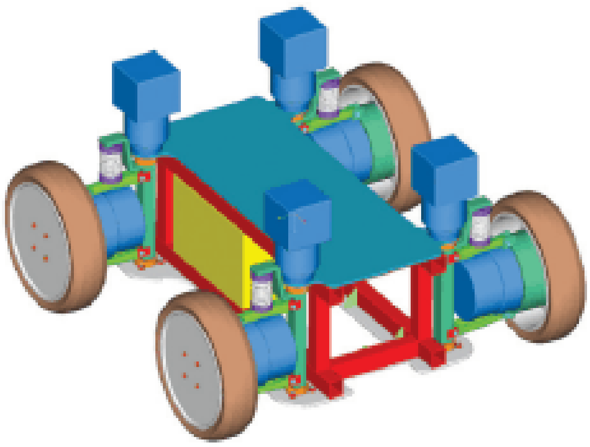

Figure 2. Schema of four-wheels mobile robot

3 DESIGN OF MOBILE ROBOTS UNDERCARRIAGE

This paper is oriented on development of flywheels robots with more degree of freedom and Ackerman control. There are described three construction applications of undercarriage for mobile robot and possibilities of their practical use.

3.1 The first version of mobile undercarriage design

The first version is three-flywheel frame with difference control (Fig. 3). This type of undercarriage has two back independent driven wheels and one floating trailing front wheel.

On the picture is three-dimensional model of the first version, which was created in CAD system SolidWorks.

The frame is hanging up on the welded square profile. On this frame are snapped two accumulators. In the back side of the undercarriage are given two electric engines, which are using for drive and direction control.

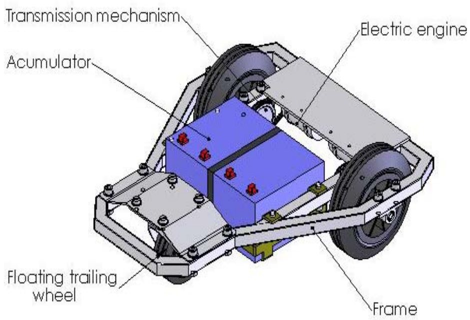

Figure 3. Three-flywheels frame with difference control

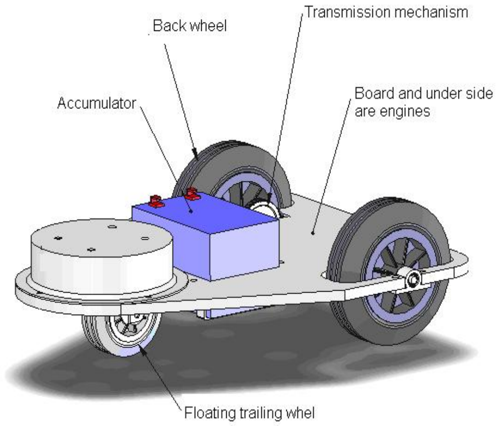

Figure 4. The second version of the mobile undercarriage

3.2 The second version of the mobile undercarriage

The base is the same as in the first version. The difference is in the frame. Mobile undercarriage is hanging up on the board (Fig. 4). This type of construction is more effective, is cheaper and construction is more easily.
This kind of undercarriage could be use in indoor application, on maintenance or reparations.

3.3 The third version of the mobile undercarriage

The third version of the mobile undercarriage is the most complicated. There is four-flywheel mobile undercarriage with more degree of freedom (Fig. 5).
Every wheel has two electric engines. One is for drive and second is for control. Two parallel axles are hanging up on the U - profile. On the frame are fixate two accumulators, two gear-boxes and eight engines for control and drive.
This type of undercarriage is able to practise different kinds of movement (rotation round the own axis). This construction has good stability, therefore it could be use in indoor application as spraying or welding robot.
In the Figure 6 are shown driving and control units in detail.

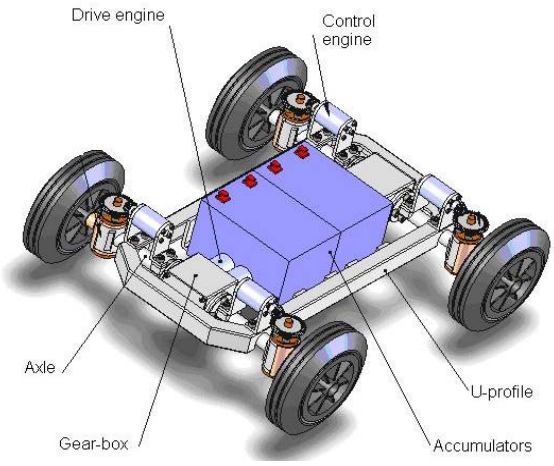

Figure 5. The four-flywheels mobile undercarriage with more degree of freedom

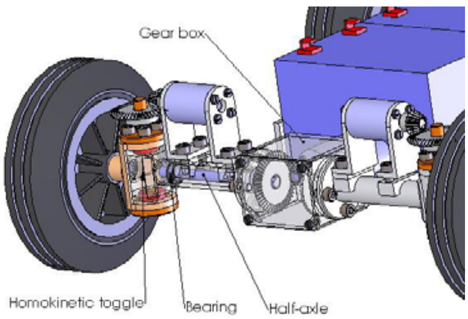

Figure 6. Driving and control unit in detail

This type of undercarriage is able to practise different kinds of movement for example drive to edgewise and rotation round the own axis.

a) *b)*

Figure 7. Mobile robot movement:
a) drive to edgewise, b) rotation round the own axis

4. CONCLUSIONS

Mobile robots have potential applications everywhere that a vehicle or a large conveyor or manipulator could be used, or already is used today – for example in medical service (hazardous material, biological waste), pharmacy automation, commercial clearing, consumer sales (supermarkets, restaurants, automated gas pump), agriculture, forestry, chemical application, lawn care, hazardous and energy (bomb mapping, nuclear plant and pipeline inspection), mining and excavation, construction and demolition, space – satellite on orbit inspection and planetary exploration, undersea – drilling platform, transatlantic cable inspection, military, shipping, material handling, security, civil transport.
The technical progression in the world of sensors and control systems is on the higher level then before, therefore today mobile robots are using on complicated application.
This paper is oriented on development of flywheels mobile robots. There were designed three construction applications of undercarriage for mobile robot and it was given possibilities of practical use. The design application of undercarriage was made in CAD system SolidWorks.

5. ACKNOWLEDGEMENT

The article was made under support of Grant Agency VEGA - project Nr.1/0046/03 and the project of MS - Applied Research Nr. 4/0002/05.

6. REFERENCES

[1] Kárník, L.: *Analýza a syntéza lokomočních ústrojí mobilních robotů*. Ediční středisko VŠB – TU Ostrava, 2004, 171 p.
[2] Kárník, L., Knoflíček, R., Novák-Marcinčin, J.: *Mobilní roboty*. Márfy Slezsko, 2000, 212 p.
[3] Kolíbal, Z., Knoflíček, R.: *Morfologická analýza stavby průmyslových robotů.* VIENALA Košice, 2000, 178 p.
[4] Knoflíček, R.: *Optimisation Methods for Driving Units of Mobile Robots*. In: ICOM 2005 Proceedings of 3rd International Congress of Precision Machining 2005, Vienna, Austria, 2005, p. 177 – 182
[5] Medvecký, Š., Čilík, L., Barysz, I., Žarnay, M., Hrčeková, A., Brónček, J. Kučera, Ľ.: *Základy konštruovania*. ŽU Žilina, 1999, 599 strán
[6] Pilc, J., Stančeková, D., Mičietová, A., Salaj, J.: *Jednoúčelové stroje a výrobné linky*. EDIS, ŽU Žilina, 2001