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**SERVICE ROBOTS FOR MAINTENANCE OF GREENERY AROUND ROADS
AND HIGHWAYS**

SERVISNÍ ROBOTY PRO ÚDRŽBU ZELENĚ KOLEM CEST A DÁLNIC

Annotation

This article presents a vision of using service robots for maintenance of greenery around roads and highways. The main goal of this vision is to eliminate the hard work, to increase the safety of traffic on roads and highways and last but not least also to keep the desired architectural and aesthetical look of the roads and preserve harmony with natural environment.

Anotace

V příspěvku je předložena vize uplatnění servisních robotů pro údržbu zeleně kolem cest a dálnic. Hlavním cílem této vize je snížení namáhavé práce při provádění údržby této zeleně, zvýšení bezpečnosti provozu na cestách a dálnicích a v neposlední řadě také udržení požadovaného architektonického a estetického vzhledu okolí dálnice a soulad stavby s okolním přírodním prostředím.

Introduction

The question of greenery maintenance will be still more and more important in the near future and we can expect need of new technologies or improvement of the current mechanisms, for example by application of service robots. In our opinion, arrangement of roads and highways also has to be changed. This means that the preliminary stage of road construction projects should include also a formulation of initial conditions for future operation. One of these conditions is certainly also requirements for future maintenance of the adjacent greenery.

Preparation, project and realization of construction of roads and highways always require a cooperation of specialists from more branches, the same way like for most of other construction activities.

Before the start of project preparations and before the start of the construction itself it is good to pay attention to specification of conditions and parameters of traffic (number of lanes in each section) and also requirements of maintenance of the structure. The final product should have long lifespan and minimal maintenance demands and thus also minimal running costs. In our case maintenance of greenery is concerned.

The current state of common maintenance of greenery around roads

Finishing procedures of road construction include arrangement of road surrounding areas and the central dividing lane of a highway. Usually this is done by grass sowing and by planting of trees and bushes. Thereby aesthetical look of the land is preserved and drivers are positively affected, noise generated by the traffic is reduced, safety of traffic is increased etc.

Overview of modifications and maintenance of greenery around roads and highways:

- creation and maintenance of grassy areas,
- creation and maintenance of hedgerows,

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- removing of shrubbery and tree species,
- wood cutting,
- creation of decorative areas,
- chemical curing of green areas,
- recultivation of devastated areas.

Greenery planted around roads and highways include primarily:

- grass on green areas,
- bushes suitable for shaping (evergreen or deciduous),
- trees.

All types of greenery around roads mentioned above require specific and regular maintenance. Shapes and dimensions of green areas together with periodicity and other detailed demands of their maintenance should be specified by specialists skilled in agriculture, even if some of the required tools are not fully satisfactory or don't even exist so far.

Existing tools for mowing of grass around roads and highways:

Various extensions for tractors and other purpose-built vehicles are used for these operations. Such specialised constructions can mow grassy vegetation around roads and highways, in ditches and on adjacent green areas. A big advantage of these mechanisms is their simplicity and also the fact that the cutting tools are resistant to impact on hard materials (stones, concrete, metal), which can often be found in ditches and around roads. Hydraulically driven arms hold and adjust cutting tools (mostly rotary cutters) to a suitable working position with range of mowing up to 5 meters.

Existing tools for cutting of bushes and trees around roads and highways:

Also for cutting of branches of bushes and trees around roads, highways, cycleways and other communications, extensions for tractors and other wheel vehicles are used. Hydraulically driven arms hold working tools that are able to cut branches in heights up to for example 6 meters. This however requires a stable construction of the machine and its application lowers the safety and smoothness of traffic, because usually the machine occupies a whole traffic lane.

In addition to the extensions mentioned above, other types of devices for processing of mowed or trimmed greenery are being developed, for instance mulching machines that are able to treat the green mass so that it can be placed on the ground below bushes etc. Special milling extensions have been developed for removing of doddered trees, bushes and their roots - the superfluous wood material is comminuted by the machine and then scattered into a delimited surrounding.

Maintenance of vegetation around roads and highways requires, especially in the vegetative period, an intensive activity of man with a lot of work. Such activities employ a lot of people who are often exposed to adverse conditions, rain, heat etc. Also the work is monotone and hard. Although there are already tools and machines that make the work easier, such as electrical and combustion mowers and cutters, they still require a human operator who must endure the noise, vibrations and exhausts and who must also take care of his health.

Preconditions for mechanized and automated maintenance of greenery around roads

Application of service robots for maintenance of greenery around roads could be much easier with some preconditions. For instance roads and highways should be already designed and built in view of the fact that service robots can be used or are going to be used on them. Figure number 1 shows a section of an existing highway that is suitable for application of service robots – a portal robot can easily mow the grass and cut the hedgerow on the central green lane, because there are no obstacles and the lane is wide enough so that the robot will not disturb the traffic on the highway. Another simplification of the maintenance operations can be brought by application of knowledges

from agriculture, for example breeding of new kinds of plants with minimal maintenance demands or with an easier maintenance.



Fig. 1: Example of a section of a highway, central green lane without crash barriers.

Technical parameters of devices designated for maintenance of grassy areas include:

- height of the grass,
- cutting height,
- mowing width,
- maximal slope of the mowed area,
- specification of obstacles that can occur in the area,
- control of the machine,
- type of actuation (internal-combustion engine etc.),
- transport of the machine between mowed areas,
- dealing with the mowed grass (mulching, collecting etc.).

While specifying the parameters of mowing, we have to envisage occurrence of other plant species than assumed on the basis of the composition of sowing. It can be various kinds of weed with higher and tougher scapes, or eventually other plants such as blackberry, raspberry and trees such as poplar, birch etc. Construction of the machine has to be adapted for such eventualities to be able to fulfill given assignments. Also there is a possibility of using chemical treatment to destroy undesirable vegetation.

Grass growing around roads is most likely not suitable for feeding of animals and thus the best way of its processing is so called mulching. Machines necessary for the proper treating with grassy areas include:

- mulching mowers,
- spreaders of grass manure and chemical substances,
- grass sweepers,
- grass aerators.

Mulching grass mowers chop blades of grass into small pieces that can be returned back to the grassy vegetation and act as green manure and also provides necessary moisture. Construction of the mower depends on height of the mowing grass, its constitution and the cutting height. For the given height of grass special cutters will be designed and also regrowing of the grass will be monitored to determine the necessary periodicity of mowing.

Appropriate mulching has following benefits:

- reduces desiccation of soil by evapotranspiration,
- minimizes occurrence of weed if around 5 centimeters high layer of mulch is used,
- soften extreme fluctuation of soil temperature,
- improves growth and vitality of plants,
- reduces erosion,
- improves soil airing and permeability,
- minimizes harm on young plants done by frost,
- can increase fertility of soil,
- can reduce accumulation of salts,
- reduces heat reflection and emission,
- reduces appearance of some diseases,
- is attractive on sight.

Selection and use of mulch must be based on needs of the plant more than on its aesthetical effect or price. Incorrect application of mulch can even damage the plants, what is a contrary of what we are trying to achieve. For further details about mulching see a series of articles [Chris Carlson, 2002].

Spreaders secure uniform dispersal of manure, chemical substances, grass seeds etc.

Grass sweepers can be constructed to collect mowed grass and pick up all waste, they should have adjustable height of sucking extensions or brushes and should be adaptable to different surfaces.

Grass aerators cautiously penetrate surface of grass and thereby they help with imbibition of moisture and manure to roots of the grass.

We can assume that automation and robotization will be also used for maintenance of bushes, hedges and trees around roads and highways. Thus man will be liberated from monotone work, plant treatment will be better and that will lead to a better look of environment.

Construction of mechanisms for maintenance of bushes and trees depends on the following parameters:

- height of the vegetation,
- length, diameter and woodiness of branches,
- width of the maintained lane,
- specification of obstacles that can occur in the area,
- control of the machine,
- type of actuation (internal-combustion engine etc.),
- transport of the machine between mowed areas,
- dealing with the waste wood (crushing and spreading or collecting and disposal).

Ways of further advancement and application of service robots

Machinery in the above mentioned spheres will continually develop and natural successors probably will be service robots. Assets of service robots are obvious already nowadays.

Application of service robots for maintenance of greenery around roads can be expected in the following operations:

1. Maintenance of grassy areas.
 - 1.1. Creation of green areas and their maintenance.
 - 1.2. Creation of decorative areas and their maintenance.
 - 1.3. Chemical treatment of green areas.
 - 1.4. Recultivation of devastated areas.
2. Maintenance of hedgerows and lines of trees.
 - 2.1. Preparation of soil and planting of hedges.
 - 2.2. Precise cutting and maintenance of hedgerows, shaping of all sides of the hedgerow (for example for heights up to 2 meters and width from 1 to 2 meters).
 - 2.3. Cutting of high trees around tree-lined roads with shaping from one side (for heights up to 6 meters).
3. Removing of stumps and other woody material.

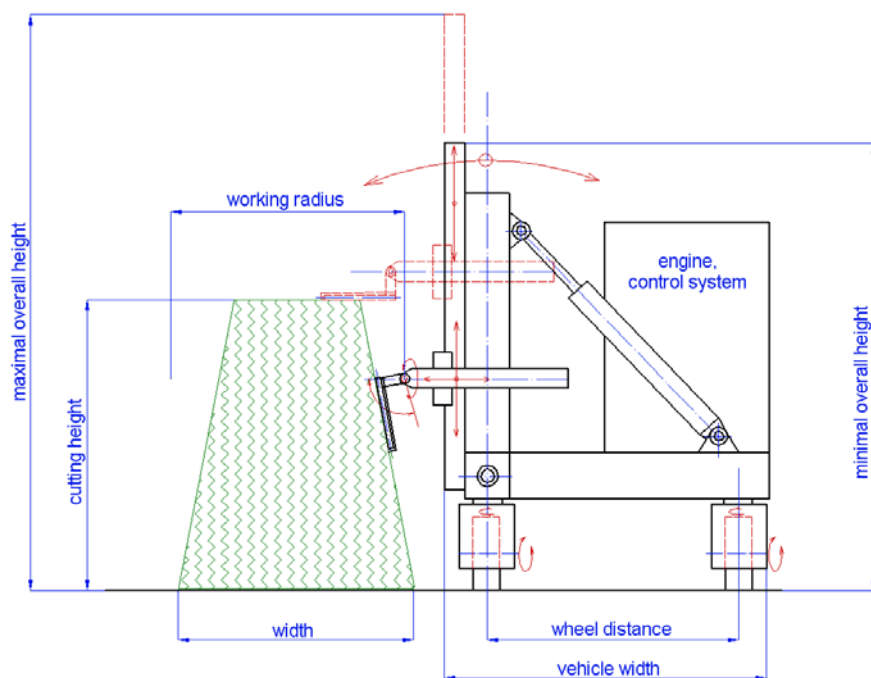


Fig. 2: A service robot with half-portal construction.

Figure number 2 shows a draft of a possible design of a half-portal service robot for cutting of hedges, bushes or trees. Position and orientation of the cutting tools can be adjusted according to the desired shape of hedge or bushes. A portal construction will be better for simultaneous cutting from both sides of a hedgerow to certain height, whereas a half-portal construction is better for higher plants, for instance for cutting of trees on tree-lined roads. The half-portal construction can be made with telescopically adjustable height and the whole telescopic pillar can be tipping. Appropriate number and configuration of adjustable axes (rotary or translatory) together with a suitable control system will allow the robot to shape bushes and trees to various geometrical shapes, which can be created as models with the assistance of computers.

Service robots designed for maintenance of greenery around roads will require appropriate control systems, sensors and actuators. Sensors that make autonomous movement in natural terrain possible are already available; various kinds of tactile sensors, ultrasonic sonars, laser distance measures and other special-purpose sensors can be used to navigate the robot and its cutting tools. Also horizontal marks on roads (side lane lines) can be used for navigation. Sensors and the control system together with construction of the robot must be able to secure the desired function (mowing, cutting etc.), safety of people and also prevent the robot from being damaged or destroyed, regardless any unexpected obstacles (road signs, stones, fallen trees, concrete or steel supports of bridges etc.) that may occur in the area.

Drives of these service robots will mostly be combustion engines, but it is also possible to design the robots as electric driven with power provided from accumulators. For such drives it is necessary to monitor the level of remaining energy in batteries. Batteries in low-performance machines can be also recharged by solar collectors.

Conclusion

So far machines for maintenance of greenery around roads and highways are operated and controlled by man. They require hard physical work although for example the main process of mowing already is mechanised. Workers are exposed to excessive noise and exhausts from the machine and from traffic on the highway and there is also a danger of accident caused by drivers on the road. The article deals with the question of maintenance of greenery (grassy vegetation, bushes, hedgerows and trees) and basic informations about necessary activities are mentioned here, together with basic parameters required for design of service robots. More specific parameters of individual service robots are not given, because these can be determined only in accordance with needs of the certain application, during construction of prototypes.

This article was compiled as part of projects FT-TA3/014, supported by the Fund for University Development from the Ministry of Industry and Trade, 2006.

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