Logisztika Napja

Logisztika 4.0 Konferencia

PRODLOG WORKSHOP

Path- and trajectory planning on an AGV

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Content

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Significance of research topic

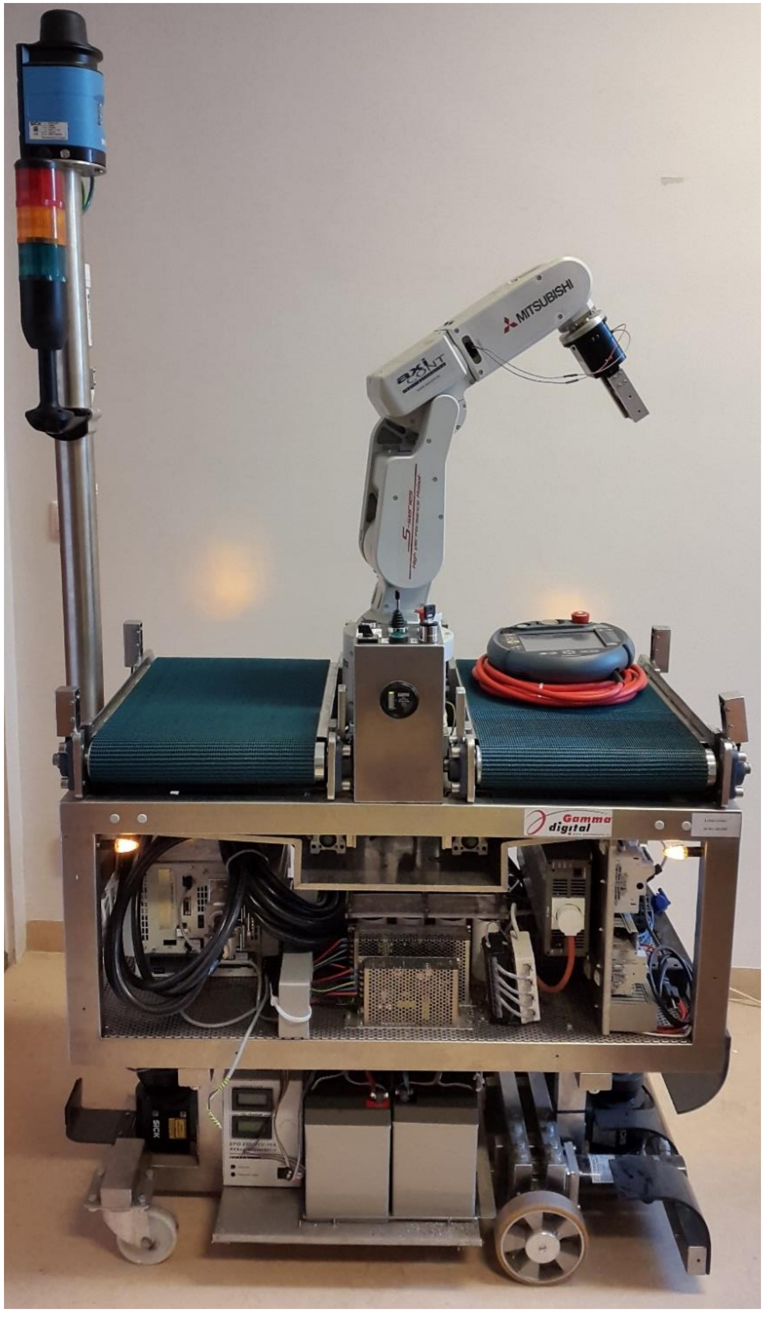
- Industry 4.0 - automatic industrial equipment
- In Hungary and the region of Northern Hungary - an increasing number of demands for robotization and automation
- Driverless transport vehicles and their automation
- Driverless transport vehicle: AGV or mobile robot
- Individual or commercially available AGV
- AGV - High-Tech Laboratory of the Institute of Logistics of the University of Miskolc

Objectives

- AGV's new path planning solution - determination of path points taking into account the geometry of the AGV
- AGV's new trajectory planner solution - calculates the velocities of the vehicle's driven wheels based on track geometry and time data

Driverless transport vehicle

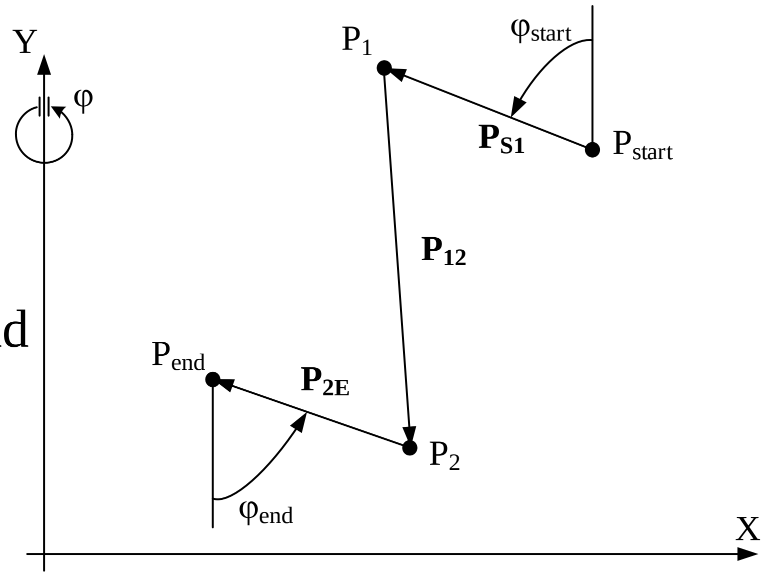
- Virtual track
- LIDAR Navigation
- Industrial robot with 6 degrees of freedom
- Conveyor belts
- 30V DC drive motors, 1:25 drive ratio
- Differential drive
- Castor wheels



Modular system used for AGV control

- **a.** path planning module
- **b.** trajectory planning module
- **c.** velocity-voltage converter module
- **d.** simulation of an electrodynamic model of a DC motor
- **e.** track simulation module
- **f.** communication module

➢ *a. Path planning module*



Baseline data for track planning

LIDAR sensor by three data:

- $\boldsymbol{P}_{start} = (X_{start}, Y_{start})$ initial position and
- φ_{start} initial orientation.

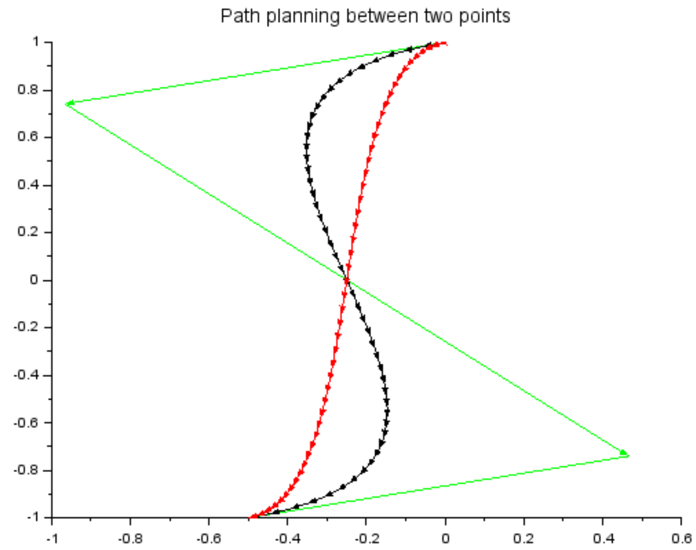
➢ User-specified target position of the vehicle:

- $\boldsymbol{P}_{end} = (X_{end}, Y_{end})$ target position and
- φ_{end} goal orientation.

Path planning solutions with cubic curves

➢ Bezier curves with Bernstein polynomial

➢ Hermite interpolation curve



➢ ***a.*** *Path planning module*

Tasks to be solved during path planning:

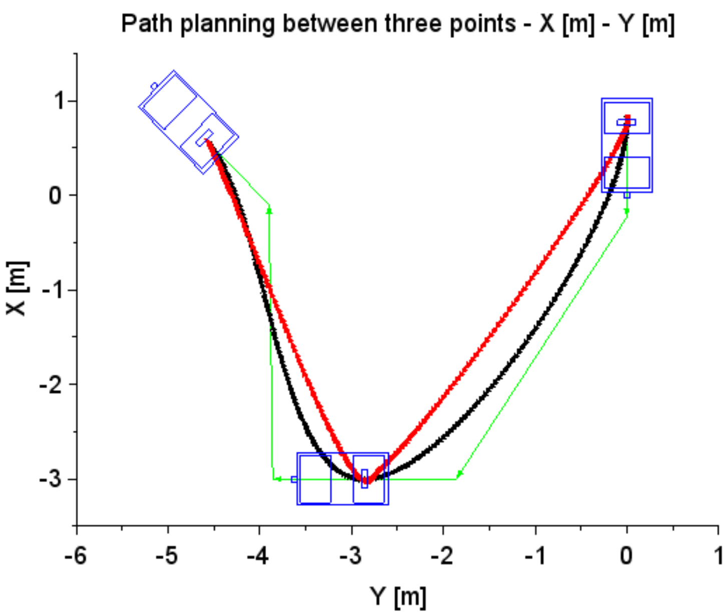
- Extra path due to approach
- Route planning to the midpoint between driven wheels
- Problem arising from approaching the final position
- Situation due to conveyor belts

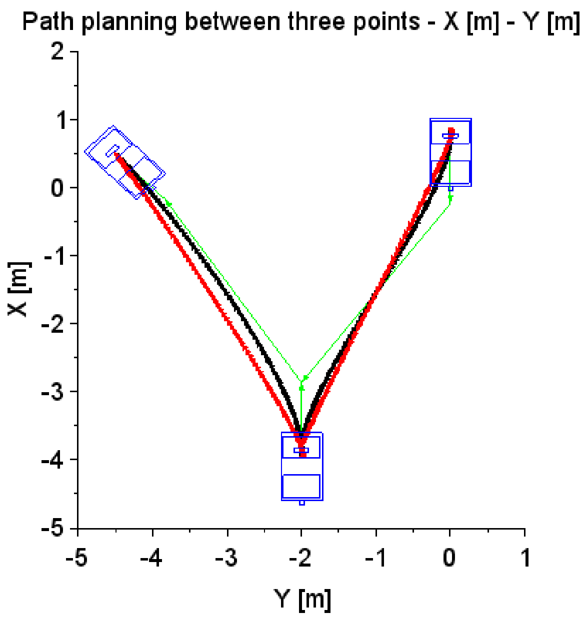
➢ ***a.*** *Path planning module*

Tasks to be solved during path planning:

- Connecting multiple segments

$$\boldsymbol{P}^{S}_{start,LIDAR} = \boldsymbol{P}^{S-1}_{end}, \text{ha } S > 1$$
$$\varphi^{S}_{start} = \varphi^{S-1}_{end}, \text{ha } S > 1$$





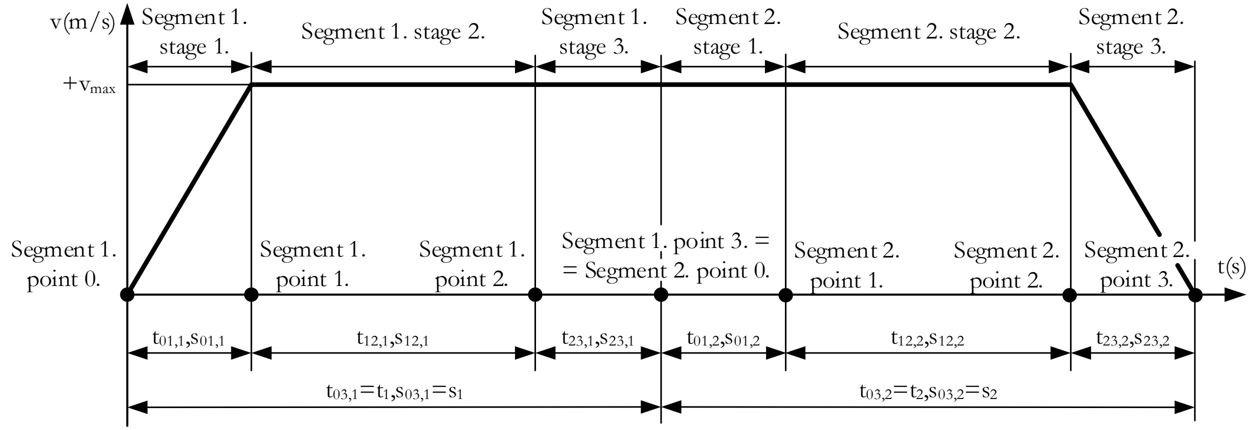
➢ ***b.*** *Trajectory planning module*

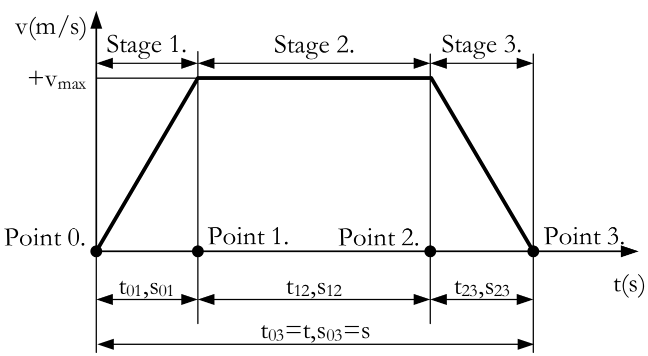
Data initially available for trajectory planning

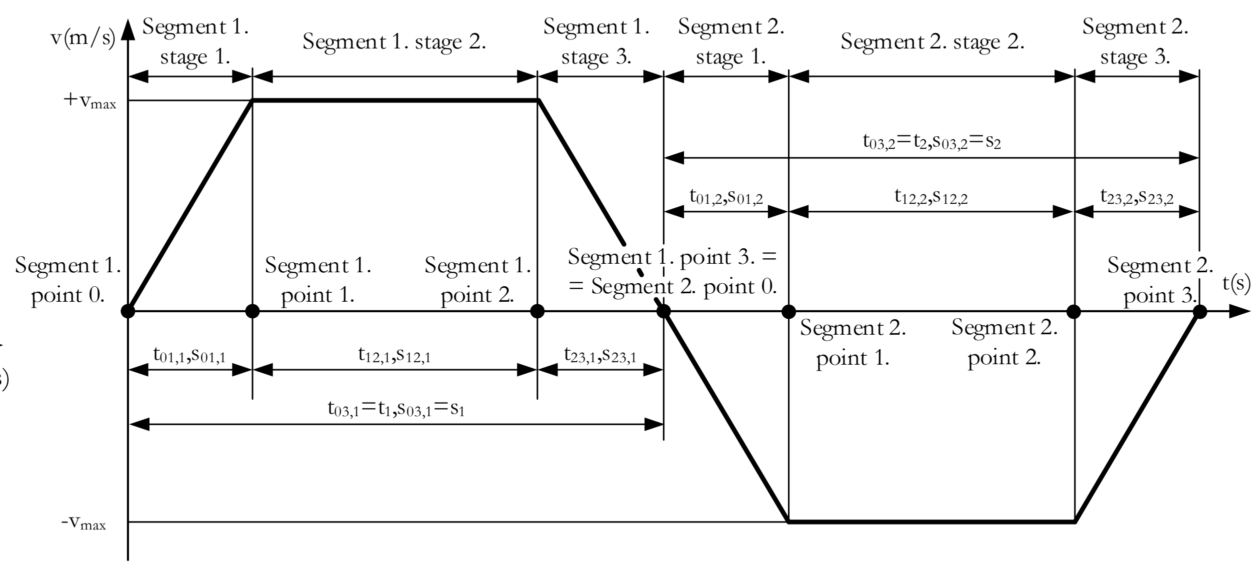
Path points

Time data

Velocity profile







➢ ***b.*** *Trajectory planning module*

Calculation of section times and path lengths required for trajectory planning

- Determining the time and distance of each section of the segment S., taking into account five different cases
- Then, based on these, determine the total time t^S of the segment

Generation of the velocity profile resulting from trajectory planning

- Determining actual path lenght $s^S_{actual}(j)$ of segment S. of path point j.
- Within each section of the segment S. determination the of time $t^S(j)$, velocity $v^S(j)$ and acceleration $a^S(j)$ for waypoints j. considering five different cases

➢ ***b.*** *Trajectory planning module*

Generation of the angular velocity profile resulting from trajectory planning

- Determining the current angle of the k-th waypoint of the entire path section
- Determination of the angular deviation between the k-th and (k-1)-th waypoints of the entire section of track
- Determination of the angular velocity $\omega(k)$ about the vertical axis through the pivot point of the truck based on the angular misalignment and time data

Generation of wheel velocities resulting from trajectory planning

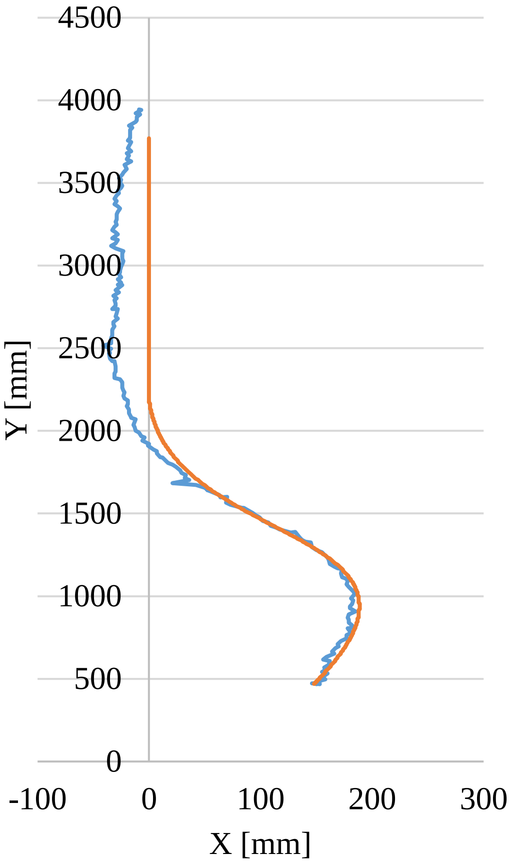
- Determining the speed of the mid-point $v(k)$ between the wheels of the AGV and the angular velocity of the vehicle $\omega(k)$ on the k-th point of the entire track section $v_R(k)$ and $v_L(k)$ on the right and left wheel, respectively:

$$v_R(k) = v(k) - \frac{b}{2} \cdot \omega(k) \ \left[\frac{m}{s}\right], \quad v_L(k) = v(k) + \frac{b}{2} \cdot \omega(k) \ \left[\frac{m}{s}\right]$$

Tests and measurements performed on the vehicle

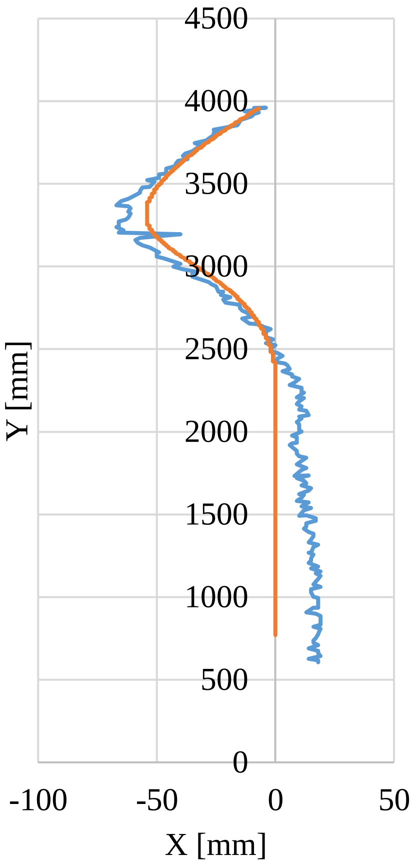
- Measurement results for automatic vehicle path control

Forward motion



Orange line: planned path
Blue line: measured path

Backward motion



Summary

In this presentation, I dealt with the path and trajectory planning of an AGV.

I highlighted the importance of the research topic and I introduced the AGV.

My development plans include the simulation and implementation of vehicle control tasks that also meet industrial needs. For further developments, I consider it important to meet the requirements of Industry 4.0 technology.

Publication

Ákos Cservenák: **Path and Trajectory Planning for an Automated Carrier Vehicle Equipped with two Conveyor Belts used in Manufacturing Supply,** Manufacturing Technology, Engineering Science and Research Journal, Institute of Technology and Production Management University of J.E. Purkyne, Vol. 21, No. 2, pp. 163-182., 20 p. (2021), **Q2 quality, Scopus indexed**

Thanks for Your attention!