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Optimization system of load transport process based on heuristic algorithms

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The working environment (Fig. 1) has additional constraints (1, 4) and obstacles (2, 3). The limitations result from the range of working movements that can be performed by the crane, while the obstacles can be interpreted as buildings or other machines located in its work zone. Forbidden areas are defined as geometric shapes (cylinders) that can be described by their height (h) and diameter (d). The optimization system allows transferring the load from the starting point P_s to the endpoint P_k by the shortest possible path while maintaining work safety.

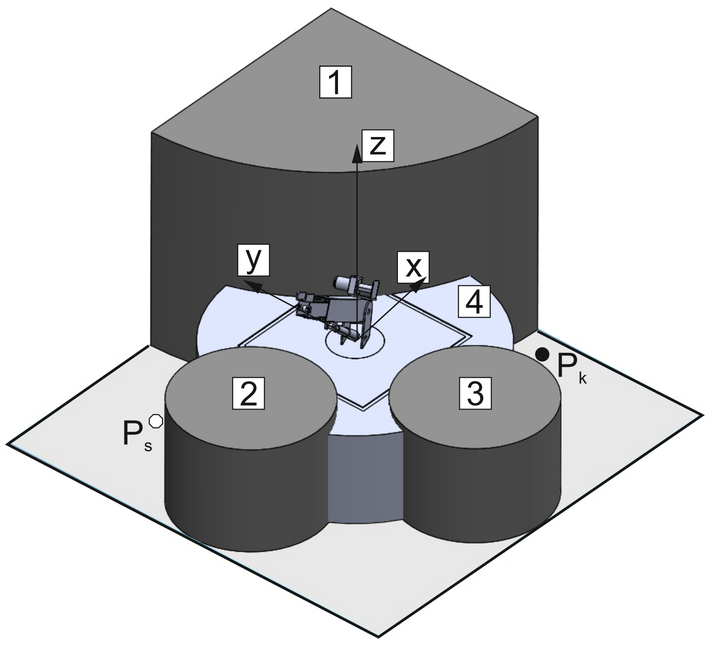


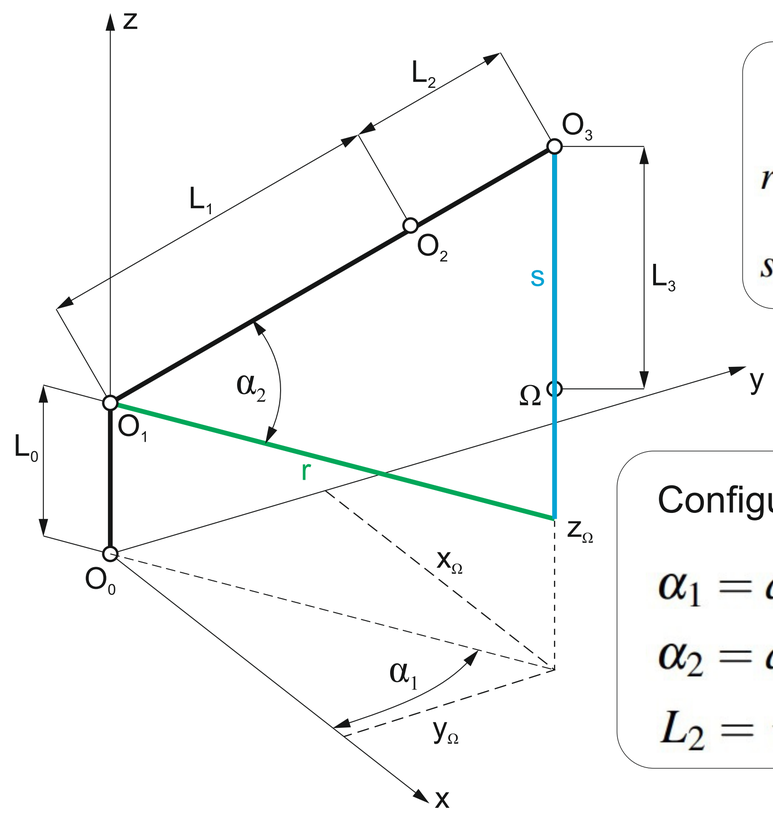
Fig. 1 Rotary crane working environment

Based on the assumptions made, the single-criteria optimization objective function has the form:

$$f_1 = L(1 + K_1) \Rightarrow min,$$

where: L - trajectory length, K1 - penalty function.

The optimization system was created using two heuristic algorithms: the classic genetic algorithm (GA) and the particle swarm optimization algorithm (PSO). Both heuristic algorithms have been implemented in Matlab software through self-written scripts and functions.



Parameters

$$r = \sqrt{x_\Omega^2 + y_\Omega^2},$$

$$s = z_\Omega - L_0 + L_3.$$

Configuration coordinates

$$\alpha_1 = atan2(y_\Omega, z_\Omega),$$
$$\alpha_2 = atan2(r, s),$$
$$L_2 = \sqrt{r^2 + s^2} - L_1.$$

Fig. 2 Kinematic diagram of the crane

The proposed optimization system calculates the shortest path using two heuristic algorithms. Depending on the choice of the algorithm, control functions are determined (Fig. 2). In the developed system, kinematic inputs are implemented by specially developed scripts implemented in the memory of the two Arduino microcontrollers. Configuration coordinates Example results for both algorithms are shown in Figures 4-6.

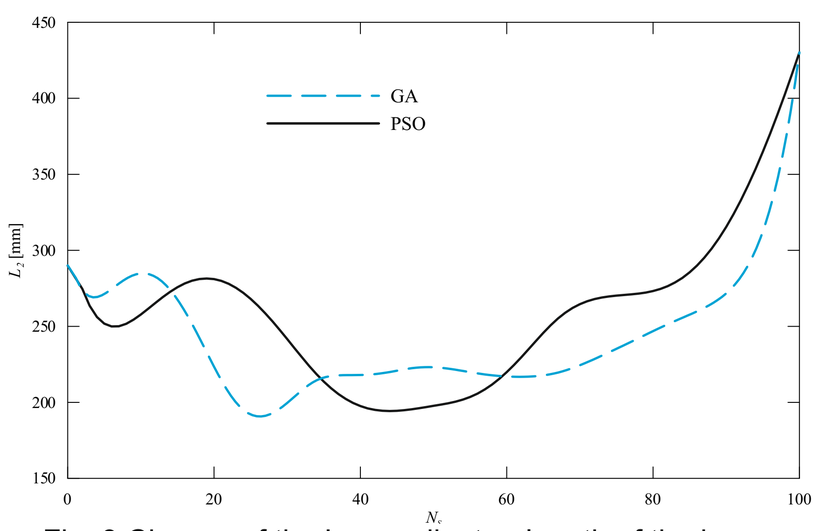


Fig. 3 Change of the L_2 coordinate - length of the boom

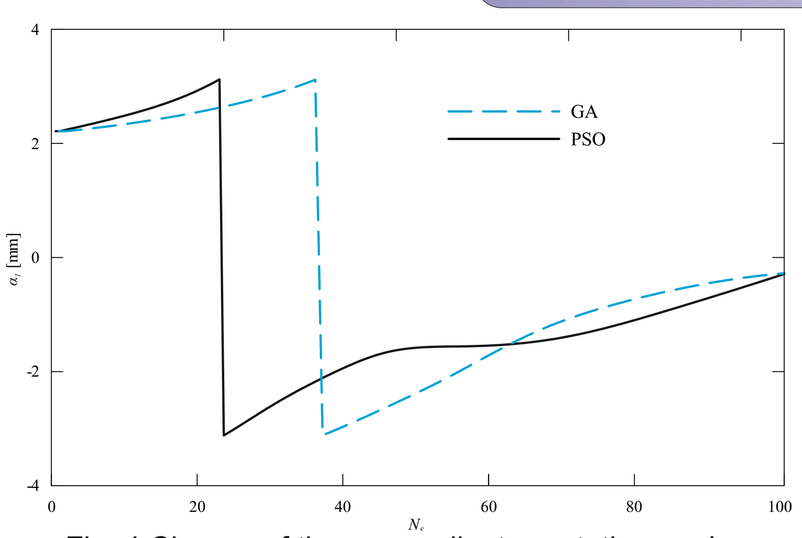


Fig. 4 Change of the α_1 coordinate - rotation angle

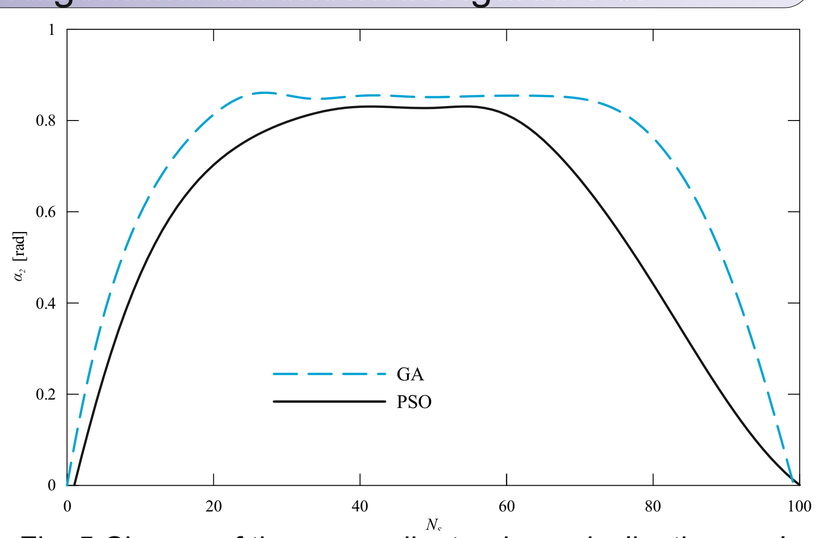


Fig. 5 Change of the α_2 coordinate - boom inclination angle

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