PARAMETER OPTIMIZATION OF THE NOT FULLY ACCESSIBLE SYSTEM OF THE HUB AIRPORT SERVICE BASED ON A SIMULATION MODEL WITH A FUZZY REGULATOR

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1. Introduction

The research object: a component of the ground transportation service system at the hub airport - its production unit, designed to perform a specific technological operation and equipped for this purpose with appropriate technological resources.

The aims of the research:

1) determination of the optimal in terms of the efficiency of the resources number required at the moments of peak load of the subsystems;

2) build a time dependence of the required number of resources over large periods of time.
2. Model of the subsystem ground handling services

Model of the input flows.
The intensity of the aircraft flow departing and arriving at the initial passenger terminal.

Probability distribution of the time interval between the time of passenger arrival to the air terminal and departure of the considered flight (gamma low):

\[
f(\tau) = \frac{1}{\Gamma(\alpha)} (\tau - c)^{\alpha-1} \beta^{-\alpha} e^{-(\tau - c)/\beta}, \quad \tau > 0, \quad \alpha = 6.1, \quad \beta = 12.6, \quad c = 20.0
\]

Service process model. The registration duration of a group of passengers (min.) is taken as a random variable distributed according to the gamma law with parameters:

\[
\alpha = 1.55, \quad \beta = 0.1 \cdot L + 0.38, \quad c = 0.1 \cdot (L + 1)
\]
3. Fuzzy control in the model of ground transportation service subsystem

Block-diagram of control system with a fuzzy logic controller

control object (CO)

membership function

defuzzification

fuzzy inference mechanism

fuzzy base of rules

control device (CD) - fuzzy controller (FC)
3. Fuzzy control in the model of ground transportation service subsystem

**Input variables of a fuzzy controller**

Measured input variables and the corresponding linguistic variables:

- \( N_i, N_i^* \) - the number of original passengers of the i-th aircraft;
- \( L_i, L_i^* \) - the number of baggage places of the initial passengers of the i-th aircraft;
- \( Z_i^\Sigma, Z_i^\Sigma^* \) - the total number of check-in places occupied by passenger services.

Membership functions of terms of input linguistic translations
3. Fuzzy control in the model of ground transportation service subsystem

Output variables of a fuzzy controller

Output variables (and the corresponding linguistic variables):

\[ p_{1i}, \ p_{2i}, \ p_{3i} \ (p_{1i}^*, \ p_{2i}^*, \ p_{3i}^*) \] - probabilities of allocating one, two, and three places for registering passengers of the i-th plane.

The terms of output linguistic variables - singleton (one-point) fuzzy sets:

\[ \tilde{p}_{1i}^B = \tilde{p}_{2i}^B = \tilde{p}_{3i}^B = p_i^B = 1 \quad \tilde{p}_{1i}^M = \tilde{p}_{2i}^M = \tilde{p}_{3i}^M = p_i^M = 0.5 \quad \tilde{p}_{1i}^L = \tilde{p}_{2i}^L = \tilde{p}_{3i}^L = p_i^L = 0 \]

Fuzzy base of rules for managing the ground handling service subsystem

| \( N_i^* \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( M \) | \( M \) | \( M \) | \( M \) | \( M \) | \( M \) | \( M \) | \( L \) | \( L \) | \( L \) | \( L \) | \( L \) |
| \( L_i^* \) | \( B \) | \( B \) | \( B \) | \( L \) | \( L \) | \( L \) | \( B \) | \( B \) | \( B \) | \( L \) | \( L \) | \( L \) | \( B \) | \( B \) | \( B \) | \( B \) | \( L \) | \( L \) | \( L \) |
| \( Z_i^* \) | \( L \) | \( M \) | \( B \) | \( L \) | \( M \) | \( B \) | \( L \) | \( M \) | \( B \) | \( L \) | \( M \) | \( B \) | \( L \) | \( M \) | \( B \) |
| \( p_{1i}^* \) | \( L \) | \( M \) | \( M \) | \( L \) | \( M \) | \( M \) | \( L \) | \( M \) | \( M \) | \( M \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) |
| \( p_{2i}^* \) | \( M \) | \( B \) | \( B \) | \( B \) | \( B \) | \( B \) | \( M \) | \( M \) | \( B \) | \( B \) | \( B \) | \( M \) | \( M \) | \( M \) | \( M \) | \( L \) | \( L \) | \( L \) | \( L \) |
| \( p_{3i}^* \) | \( B \) | \( B \) | \( M \) | \( M \) | \( M \) | \( L \) | \( B \) | \( M \) | \( L \) | \( M \) | \( L \) | \( L \) | \( L \) | \( L \) | \( L \) | \( L \) | \( L \) | \( L \) | \( L \) |

B - “large number”, M - “medium number”, L - “small number”
4. Setting the optimization problem

In the time interval \([0, T)\) it is required to determine the time dependence of the optimal number \(z_{opt}(t)\) of resources of the same type in an incompletely accessible service system with the characteristics described in part 2, using fuzzy control considered in part 3. Optimal means the minimum number of check-in sites sufficient for the airport to start timely performing this operation with a given \(P\) reliability, provided that the check-in of passengers to the \(i\)-th aircraft begins only if there are \(Z_i\) free places determined by a dispatcher.
5. Results of a model example of an optimization problem solution

$z_{opt}(t)$ - time dependence of the optimal number of resources;

$\overline{Z}(t)$ - time dependence of the average number of registration sites;

$\overline{T}_w(t)$ - average waiting time in the queue for the registration of passengers;

$N_w^{0.99}(t)$ - time dependence of 0.99-quantile the number of passengers in the queue and the service in the check-in area
6. Conclusion

Simulation modelling allows us to create a detailed stochastic portrait of functional subsystems of hub airport.

Using FC to simulate the behaviour of a dispatcher who controls airport processes makes it possible to increase the adequacy and accuracy of simulation models.

Optimization of the parameters of functional subsystems may allow airport services to provide rational solutions for tasks:
- operational resource manoeuvring,
- redistribution of forces and resources between subsystems,
- planning staff shift work,
- calculating the required number of shifts ats.
7. References