Politechnika Wrocławska

A method for managing a security checkpoint through multi-criteria analysis with consideration of safety and process performance

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HR EXCELLENCE IN RESEARCH

Project co-financed by the European Regional Development Fund under the Operational Programme Intelligent Development

The aim of the project

The aim of the project is to increase the level of civil aviation security through the development of an innovative method of training and evaluation of security control operators.

Main tasks:

- the identification of factors that affect the effectiveness of interpreting images obtained from an X-ray machine;
- the identification of factors affecting the effectiveness of interpreting a passenger's attempt to conceal items carried or behavior indicative of an attempt to conceal such items;
- development of algorithms to train and evaluate screening operators to meet required standards when performing duties on a real system;
- developing software and a training station;
- conducting scientific research to verify the effectiveness of the developed solution.

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Problem background

The main disadvantages of the current training system are:

- training of operators takes place under conditions different from the operator's workplace,
- too low qualification of operators who start work directly after undergoing training and passing exams,
- too long process of acquiring the required level of qualifications in the course of performing security control tasks;

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System concept

1. Development a model to evaluate the training process of a screening operator
2. Development dynamic algorithm of changing the training level during the training session
3. Development of image libraries
4. Development of a method to generate an image of screened baggage
5. Development of an image ranking model
6. Development of a model for operator image evaluation during the training and retraining process
7. Development of a simulation model of screening station operation
8. Developement of a method for configuring the screening system

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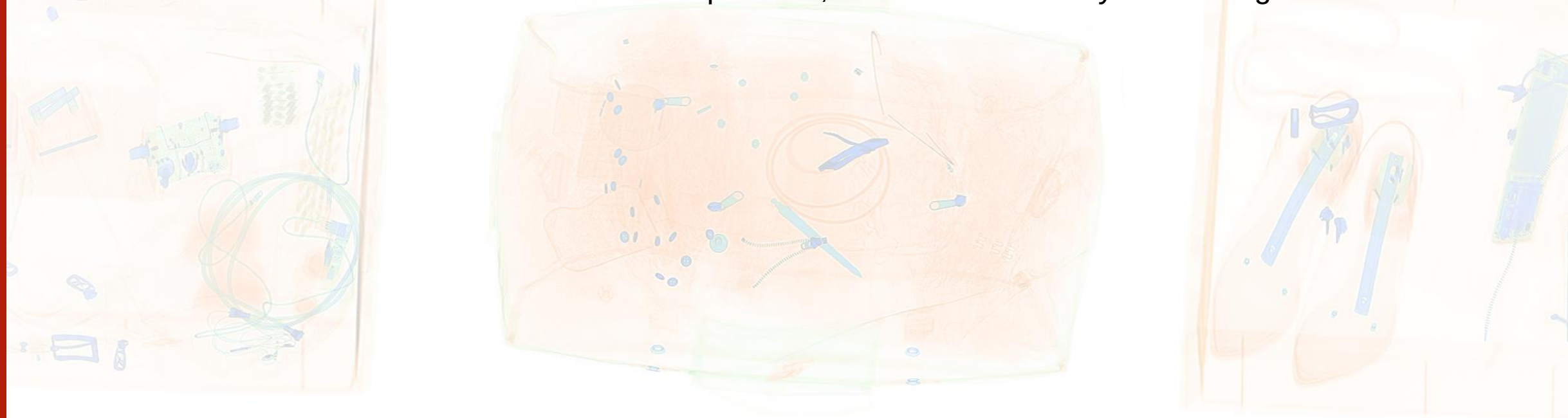
Evaluation model of security lane configuration

The purpose of this paper is to develop a method for configuring a security screening lane at an airport. The method will be based on such personnel management that the most advantageous ratio of safety to process performance is achieved. The paper uses a fuzzy model on the basis of which a multi-criteria analysis is conducted. Two criteria are taken into account: safety and process performance. The model allows to select a team from a set of available operators, to obtain the best system configuration.



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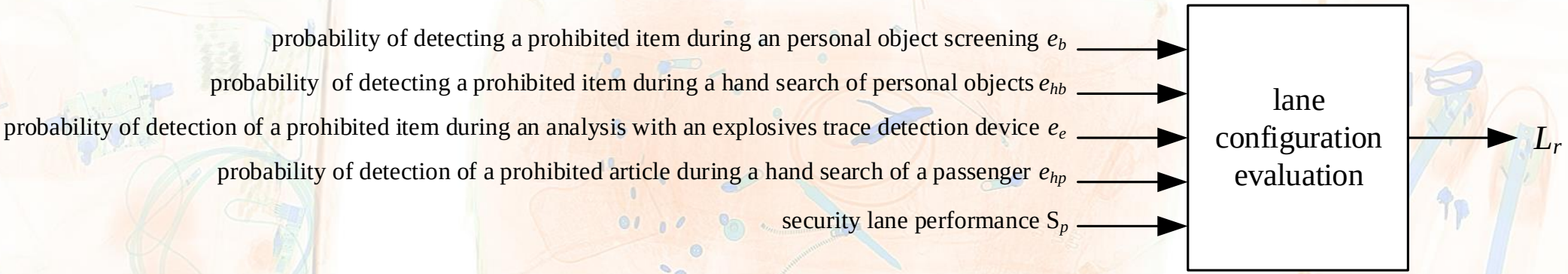
Fuzzy model concept

We propose a multi-criteria evaluation method in which the system evaluation by fuzzy model consists of 5 input criteria



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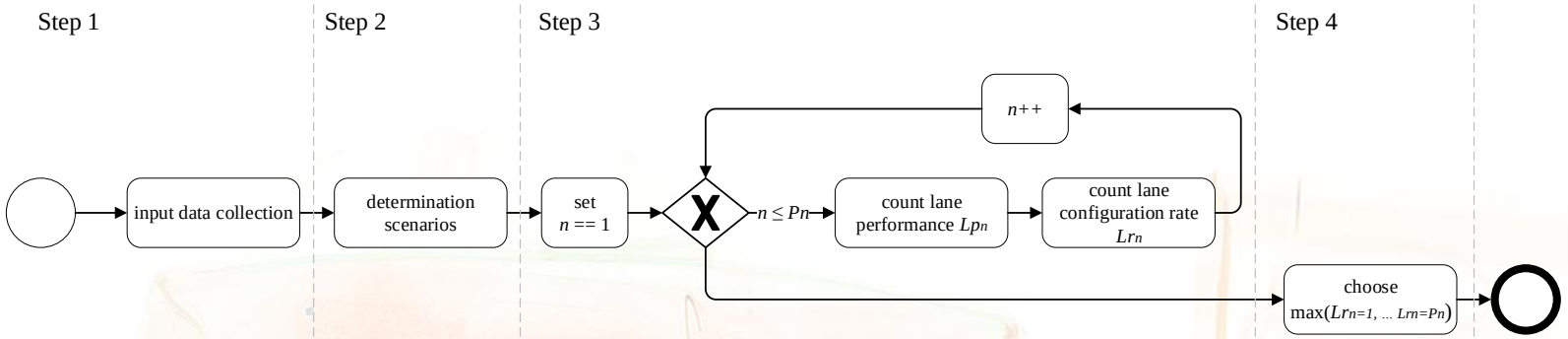
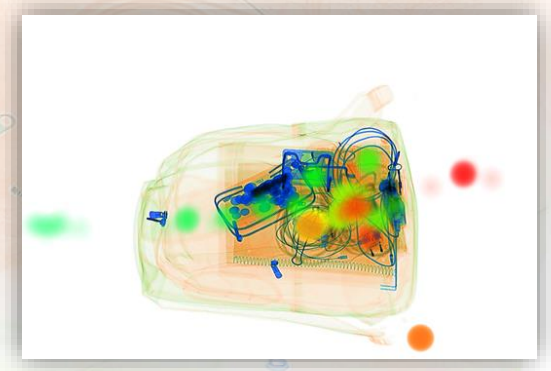
Evaluation model of security lane configuration

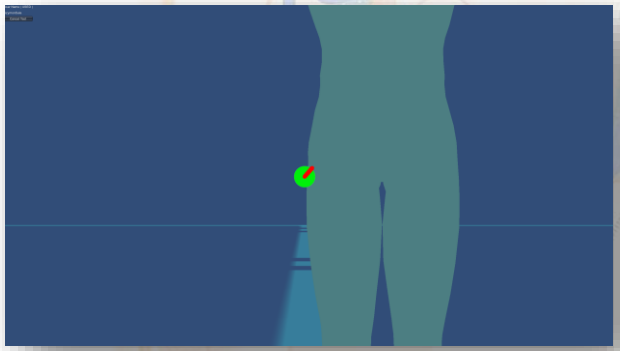
Methodology



Step 1 Input data collection

Step one is to collect data on screening operators. For this purpose, the results of the research from our training system will be applied. We will collect data on the probability of detecting objects and on the timing of preforming each activity.





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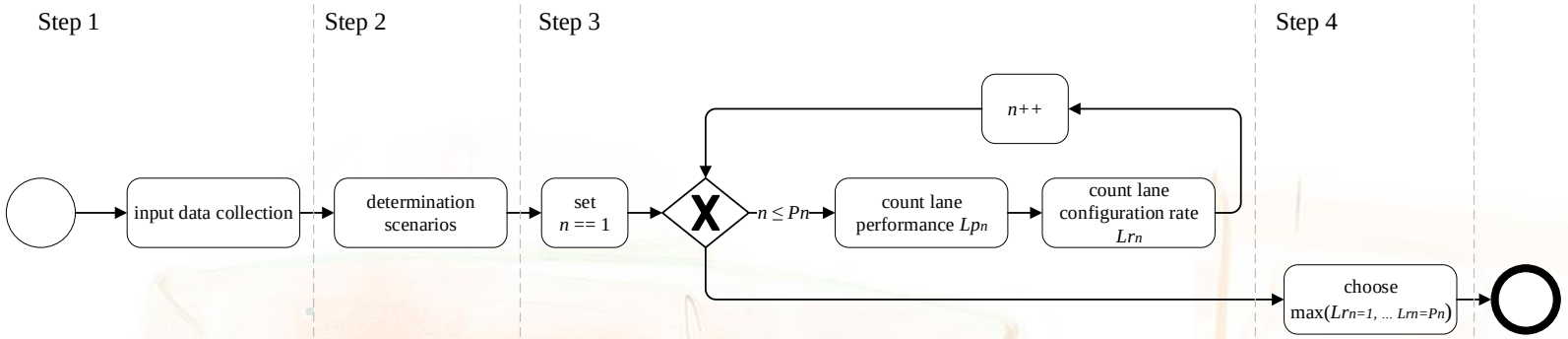

Step 2 Determination of scenarios

In this step, all possible combinations of system configurations must be determined. From the set of available operators can be selected 3 operators, each of which will be responsible for a different task:

- OS1 - performs manual control of passengers,
- OS2 - performs baggage screening
- OS3 - performs extended baggage inspection.

$$Pn = \frac{i!}{3!\,(i-3)!} * 3!$$

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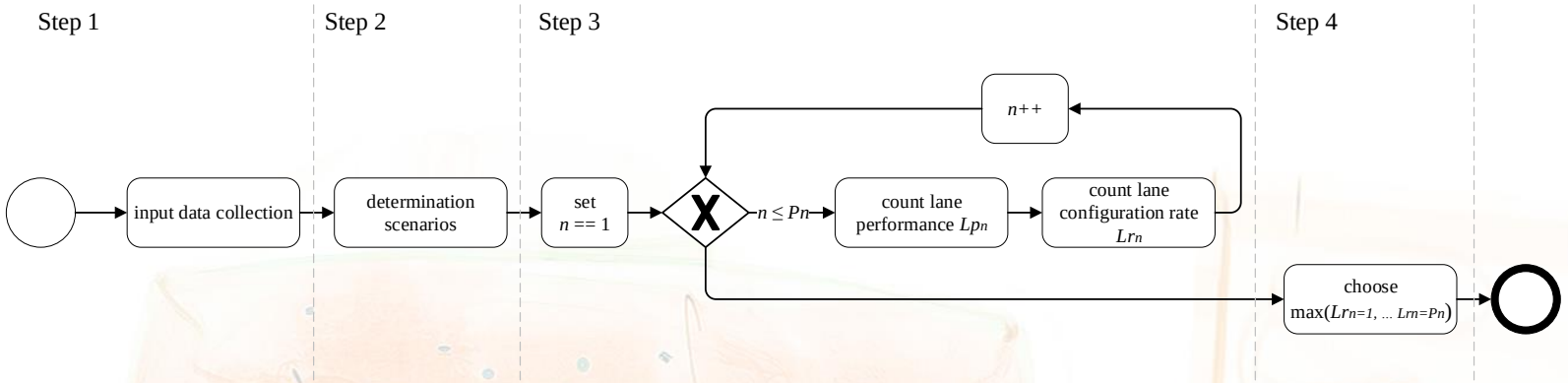
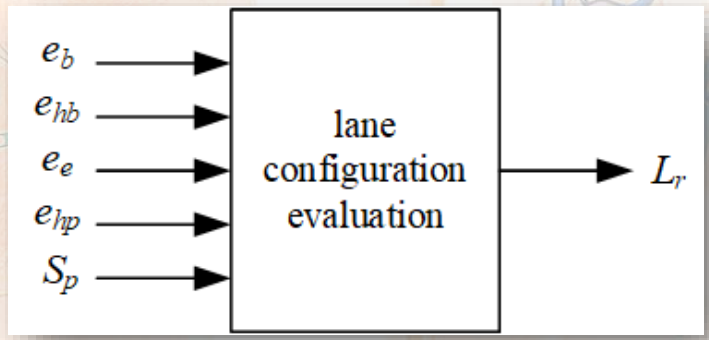


Step 3 Calculation of ratings for all system configurations Indicators determined from the screening operator's training system are entered directly as input variables: e_b, e_{hb}, e_e, e_{hp}. The last variable that is entered into the fuzzy model is its performance S_p. This parameter must be determined.



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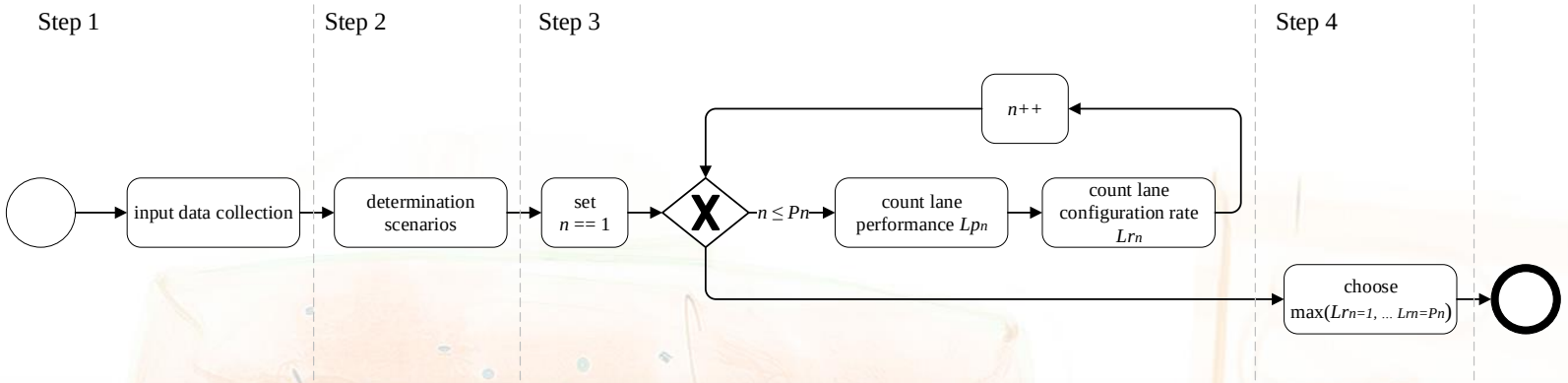

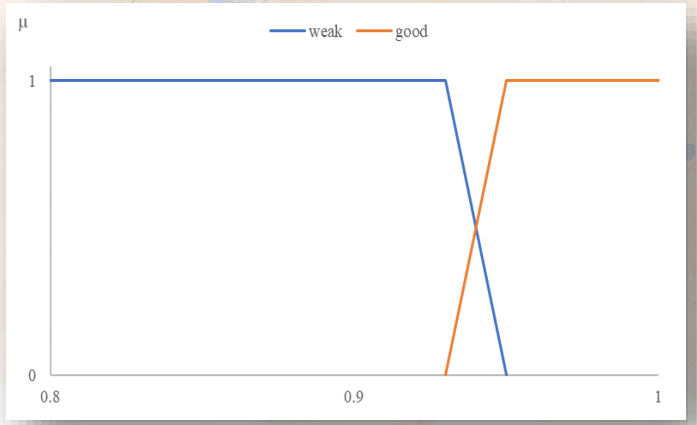

R1	if(	e_b	is	weak	) AND (	e_{hb}	is	weak	) AND (	e_e	is	weak	) AND (	e_{hp}	is	weak	) AND (	S_p	is	low	) then (	S_r	is	low	)
R2	if(	e_b	is	weak	) AND (	e_{hb}	is	weak	) AND (	e_e	is	weak	) AND (	e_{hp}	is	weak	) AND (	S_p	is	medium	) then (	S_r	is	low	)
R3	if(	e_b	is	weak	) AND (	e_{hb}	is	weak	) AND (	e_e	is	weak	) AND (	e_{hp}	is	weak	) AND (	S_p	is	high	) then (	S_r	is	low	)
R4	if(	e_b	is	good	) AND (	e_{hb}	is	weak	) AND (	e_e	is	weak	) AND (	e_{hp}	is	weak	) AND (	S_p	is	low	) then (	S_r	is	low	)
R5	if(	e_b	is	good	) AND (	e_{hb}	is	weak	) AND (	e_e	is	good	) AND (	e_{hp}	is	weak	) AND (	S_p	is	low	) then (	S_r	is	low	)
R6	if(	e_b	is	good	) AND (	e_{hb}	is	weak	) AND (	e_e	is	good	) AND (	e_{hp}	is	weak	) AND (	S_p	is	medium	) then (	S_r	is	medium	)
R7	if(	e_b	is	good	) AND (	e_{hb}	is	good	) AND (	e_e	is	weak	) AND (	e_{hp}	is	weak	) AND (	S_p	is	medium	) then (	S_r	is	medium	)
R8	if(	e_b	is	good	) AND (	e_{hb}	is	good	) AND (	e_e	is	good	) AND (	e_{hp}	is	weak	) AND (	S_p	is	medium	) then (	S_r	is	medium	)
R9	if(	e_b	is	good	) AND (	e_{hb}	is	weak	) AND (	e_e	is	weak	) AND (	e_{hp}	is	good	) AND (	S_p	is	medium	) then (	S_r	is	medium	)
R10	if(	e_b	is	good	) AND (	e_{hb}	is	good	) AND (	e_e	is	weak	) AND (	e_{hp}	is	good	) AND (	S_p	is	medium	) then (	S_r	is	medium	)
R11	if(	e_b	is	good	) AND (	e_{hb}	is	good	) AND (	e_e	is	good	) AND (	e_{hp}	is	good	) AND (	S_p	is	medium	) then (	S_r	is	high	)
R12	if(	e_b	is	good	) AND (	e_{hb}	is	good	) AND (	e_e	is	good	) AND (	e_{hp}	is	good	) AND (	S_p	is	high	) then (	S_r	is	high	)

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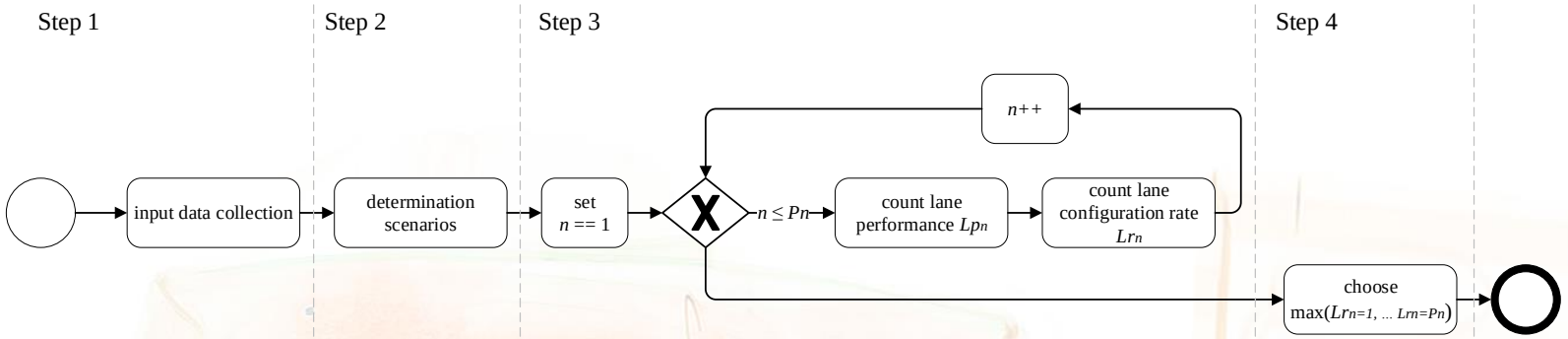
Evaluation model of security lane configuration

Methodology



Step 4 Selecting the best configuration From the set of system evaluation results L_r for all consecutive configurations, the largest value of the obtained *Lr* is selected

$$S_r = max\left(L_{r_{n=1}}, \ldots, L_{r_{n=P_n}}\right)$$

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Evaluation model of security lane configuration

Methodology verification

The results obtained, through validation, indicate that there is a high correlation between the ratings proposed by the model and the average rating given by the experts. The average difference between the fuzzy model ratings and the experts' ratings is 0.19 which represents an error of magnitude of 3.5%.

No.	configuration			entry parameters					output parameters		linguistic output parameters	
	(Operator No.)			e_b	e_{hb}	e_e	e_{hp}	S_p	L_{rm}	L_{re}	(fuzzy model)	(experts)
1	o2	o1	o3	0.95	0.94	0.97	0.88	145	4.20	4.35	high	high
2	o2	o4	o3	0.95	0.99	0.97	0.88	141	4.15	4.20	high	high
3	o1	o2	o3	0.92	0.96	0.97	0.88	144	4.07	4.20	high	high
4	o4	o2	o3	0.90	0.96	0.97	0.88	143	4.07	4.10	high	high
5	o3	o1	o4	0.87	0.94	0.94	0.94	140	3.76	3.95	medium/high	medium/high
6	o4	o1	o3	0.90	0.94	0.97	0.88	135	3.68	3.95	medium/high	medium/high
7	o1	o4	o3	0.92	0.99	0.97	0.88	130	3.51	3.80	medium/high	medium/high
8	o3	o4	o2	0.87	0.99	0.99	0.99	128	3.39	3.80	medium/high	medium/high
9	o2	o3	o1	0.95	0.95	0.98	0.86	131	3.27	3.60	medium/high	medium/high
10	o1	o4	o2	0.92	0.99	0.99	0.99	132	2.99	3.50	medium	medium/high
11	o1	o3	o2	0.92	0.95	0.99	0.99	125	2.86	3.15	medium	medium/high
12	o4	o3	o2	0.90	0.95	0.99	0.99	124	2.74	3.05	medium	medium/high
13	o4	o1	o2	0.90	0.94	0.99	0.99	123	2.64	2.80	medium	medium
14	o2	o4	o1	0.95	0.99	0.98	0.86	119	2.53	2.60	medium	medium
15	o2	o3	o4	0.95	0.95	0.94	0.94	118	2.51	2.55	medium	medium
16	o2	o1	o4	0.95	0.94	0.94	0.94	118	2.50	2.55	medium	medium
17	o3	o2	o4	0.87	0.96	0.94	0.94	116	2.50	2.50	medium	medium
18	o3	o4	o1	0.87	0.99	0.98	0.86	117	2.50	2.50	medium	medium
19	o4	o3	o1	0.90	0.95	0.98	0.86	116	2.50	2.35	medium	medium
20	o3	o1	o2	0.87	0.94	0.94	0.94	114	2.50	2.40	medium	medium
21	o3	o2	o1	0.87	0.96	0.98	0.86	124	2.30	2.50	medium	medium
22	o1	o3	o4	0.92	0.95	0.94	0.94	120	2.30	2.25	medium	medium
23	o1	o2	o4	0.92	0.96	0.94	0.94	118	2.13	2.00	medium	medium
24	o4	o2	o1	0.90	0.96	0.98	0.86	110	1.68	1.85	low/medium	low/medium

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Summary

- This paper presents a method that allows to select the optimal assignment of tasks to security screening operators
- In this method, two factors are taken into account simultaneously: safety and performance
- the method is based on a fuzzy logic model that has been configured with the knowledge of highly experienced operators and trainers
- the method has been validated on the made-up sample data
- we are now working on integrating the model into our training station to test the model in real life conditions

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Thank you for your attention.

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Rzeczpospolita Polska
Unia Europejska Europejski Fundusz Rozwoju Regionalnego

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