

Description for the general public

The main goal of the project is to develop new intelligent and flexible methods for solving problems related to the optimal location of facilities in production management and logistics. The facilities layout is a general term for a very practical task, present both in everyday life and in designing production machines and systems, service buildings etc.

Objects that should be rationally located are, for example, furniture and kitchen appliances, machines and equipment in production cells, or aircraft indicators and controls. The rationalization of the kitchen layout consists in arranging the elements of equipment and furniture in relation to each other so that, when preparing meals, one does not need to walk unnecessarily. If we know the recipe for making a dish, we know which elements of the kitchen need to be used and in which order. Having such information about all the dishes made, we know the estimated number of transitions between each pair of equipment items. We can also conclude about the amount and range of hand movements associated with the use of kitchen utensils and tools, semi-finished products, spices, etc. The optimal arrangement of all objects in such a situation should ensure the shortest path during cooking and the least amount of energy spent on work movements.

Looking more broadly, it can be seen that the arrangement providing the smallest walking distance can create a non-aesthetic layout, or some elements ought to be better illuminated with daylight and should be located elsewhere. The optimization of walking is objectively measurable, but the aesthetics of kitchen arrangement or better lighting are more subjective and qualitative. Therefore, designing the optimal placement of objects is a task that requires consideration of many different points of view called criteria. The tasks of facilities layout in production systems are also of a similar nature. The objects there are usually devices and machines whose placement is optimized due to the costs of transporting products and materials between them (logistics), but also because of safety, supervision, ease of use, shapes.

In classic algorithms generating facilities layout solutions, only objective criteria were considered. The direction of research, however, aims to take into account the subjective aspects more and more often. Subjective assessments regarding the kitchen example are best obtained from a chef - an expert or a whole team of users. Considering such expert knowledge in algorithms seeking the best locations for many different criteria, constitute the first area of interest in the proposed project. Appropriate representation of knowledge in forms close to a natural language, makes it possible to include both measurable and qualitative criteria in the search for the best solutions.

The second area of planned activities is the search for new algorithms for problems with the hierarchical arrangement of objects. In the kitchen example, it would be advisable to take into consideration, in addition to the location of individual furniture, their structure and the arrangement of kitchen tools. Such a two-step approach would minimize both the cost of walking and work movements. In production systems of this type, the analysis allows for optimizing the arrangement of production cells within the department, and the layout of machinery and devices inside the cells.

The flexibility of the algorithms is associated with the minimization of the restrictions to which they are subject. The proposed direction of the development of methodology for generating scattered plots does not require any assumptions as to the shape and predefined location of objects to be included in the layout. Obtained diagrams will show mutual relations of objects' neighborhoods and their distances according to the criteria used while generating solutions. These criteria, in the proposed new approach, can be formulated by an expert in a form similar to expressions and relationships from a natural language. For the kitchen example, acquiring knowledge from experts about mutual objects' relations, e.g. in the form of phrases like *very closely related*, *similar*, *often used* etc., will allow to generate scatter plots suggesting the best furniture, appliances and kitchen tools neighborhoods. Such a sketch can be a basis for designing a specific arrangement.

The proposed approaches to the analyzed problems fall within the domain of artificial intelligence research. Because they are aimed at expanding flexibility, including more aspects determining the solutions' quality and using the practical knowledge of experts, they will allow for bringing computer models closer to real-life situations and actual needs of practice.