

ДОМЕННИЙ АНАЛІЗ

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O.V. Chebanyuk, V.I. Chuprinka

ONE APPROACH OF CONSTRUCTING PROBLEM DOMAIN METAMODEL

The requirements of modern standards for constructing problem domain metamodel and approach of construction problem domain metamodel, which is based on the method engineering are considered in this article. The metamodel of problem domain - "constructing cutting schemes of rolled materials based on layouts" which are built on thick laying is constructed. The peculiarities of the next algorithms for the following subdomains "constructing of laying for shoe details" and "constructing of laying for leather goods details", which are meet technological requirements and limits, are considered.

В роботі проаналізовано вимоги сучасних стандартів щодо побудови метамоделі проблемного домену, показано підхід до побудови метамоделі, що ґрунтується на засобах інженерії методу. Побудовано метамодель проблемного домену – «проектування розкрійних схем рулонних матеріалів на основі розкладок», що базуються на щільних укладках. Розглянуті особливості алгоритмів побудови розкладок наступних піддоменів «побудова розкладок деталей виробів взуття» та «побудова розкладок схем для деталей виробів шкіргалантереї» з дотриманням технологічних вимог та обмежень.

В роботі проаналізовані вимоги сучасних стандартів побудови метамоделі проблемного домену, показано підхід до побудови метамоделі, який ґрунтується на засобах інженерії методу. Побудовано метамодель прикладного домену – «проектирование раскройных схем рулонных материалов на базе раскладок», которые строятся на плотных укладках. Рассмотрены особенности алгоритмов построения раскладок для следующих поддоменов «построение раскладок для деталей обуви» и «построение раскладок для деталей изделий из кожгалантереи» с соблюдением технологических требований и ограничений.

Key words metamodel, method engineering, ISO/IEC 24744, layout, cutting schema

Methodology metamodel A metamodel defines the language for expressing the model. It can describe concepts and their relationships for the purpose of building and interpreting models that themselves are an abstraction of reality: "A metamodel is the collection of "concepts" (things, terms and so on) that are the vocabulary with which you are talking about a certain domain." [1]. UML itself is an example of such metamodel defining concepts with which one can to model systems [2]. Metamodel often looks like the class or package diagram. It helps to build concrete architecture of some application taking some classes from problem domain framework for solving particular task. If the metamodel was built according to requirements of modern standards [3,4] and LEAN [5] approach it can reduce the development time, be close to agile approach, and help to construct more effective and stable software modules. Review the standards of metamodels problem domain constructing

The standard ISO/IEC 24744 (Software Engineering -- Metamodel for Development Methodologies) requires building a metamodel of problem domain using and analyzing the next artifacts:

–Lifecycle diagrams, which represent the overall structure of a method (or part of it).

–Enactment diagrams, which represent a specific endeavor (or part of it) and its relationship to the corresponding method.

–Dependency diagrams, which represent the abstract support/dependency relationships among the major components (i.e. producer kinds, work unit kinds and work product kinds) of a methodology.

–Process diagrams, which describe the details of the process kinds used in a method.

–Action diagrams, which show the detailed usage interactions between task kinds and work product kinds [3].

–The "Business Process Definition Metamodel" (BPDM) is a framework for understanding and specifying the processes of an organization or community. Business processes have been at the heart of business and technology improvement under the guise of many terms and methodologies, such as: Business Process Engineering or Re-Engineering, Business Process Management, Business Process Execution, Total Quality Management, Process Improvement, Business Process Modeling, and Workflow. Similar and related concepts such as Service Oriented

Architectures, Enterprise Application Integration, Flowcharts, Data Flows, Activity Diagrams, Role/Collaboration Modeling, and Modeling and Simulation serve to enable and describe business processes [4].

To achieve this goal, BPDM supports two fundamental and complementary views of process – “Orchestration” and “Choreography”:

–Orchestration concepts in BPDM are represented through sequences of “Activities” that produce results with branching and synchronization. Orchestration is typically represented as flow charts, activity diagrams, swim lanes, or similar notations of one task or activity following another. The orchestration of processes describes what happens and when in order to better manage a process under the authority of some entity.

–Choreography describes how semi-independent and collaborating entities work together in a process, each of which may have their own internal processes. Choreography captures the interactions of roles with well-defined responsibilities within a given process. Choreography is the basis for the Service Oriented Architecture (SOA) paradigm and helps to keep the enterprise loosely coupled and agile. The choreography of a process focuses on the responsibilities and interactions that ultimately provide value without necessarily requiring any coordinating authority. In business process modeling, choreography and orchestration are effectively two sides of the same coin. BPDM joins orchestration and choreography into a unified and coherent model.

Making the summary of BPDM approach it’s important to notice, that the BPDM model is a model of the business, not the technology, but MDA helps join these two viewpoints.

The task to build the metamodel of chosen problem domain “designing the layout of cutting schemas” according to standards **ISO/IEC 24744** and **BPDM** framework. The metamodel can look like ontology of dsl language. The metamodel should allow to build another models for illustration the relationships between entities of subject domain and facilitate the action of processes analyzation.

Requirements toward the result of researches Proposed metamodel should be capable:

–describe other conceptual models, e.g., the ER model and Structured Analysis and Design Technique (SADT) models;

–support facilities for defining primitive concepts (entity, activity, goal);

–offer support for modeling multiple, possibly contradictory perspectives;

–support a variety of referential relationships [6].

–satisfy the modern standards of building metamodels and processes analysis.

Steps of building problem domain metamodel “designing cutting schemas for shoe details and leather goods details”

Common features of this problem domains

As two problem domains have common entities and problems consider them first.

The first step is to built lifecycle diagrams, which represent the overall structure of a method (or part of it) like first step of building metamodel of studied domain. The definition of method is based of method software engineering [6] and looks as (figure 1).

The metamodel domain is usually composed of standardized conceptual constructs, the method domain contains real-world methodology elements (methods, tools, coding standards) while the endeavor domain represents actual processes in use by the Standardizing Methodology Metamodelling and Notation.

Referring to definition of methodology like “a system of broad principles or rules from which specific methods or procedures may be derived to interpret or solve different problems within the scope of a particular discipline” [7,8] one can underline problems of problem domain and also main procedures and methods.

Tasks of problem domains : to solve three subtasks find a way of representation layout (the proper math model) [9], the algorithm of layouts’ dense combination [10], to check layout in accordance with technological limitation [10].

Principles and roles of problem domain

Layout is a regular placing of the one type of details on the strip width less than the width of the material. Sections are composing of layouts. Also sections are parts of scheme cut roll materials.

Mathematical model of layout is single or double rectangular grid, which is defined by three vectors: a_1 -vector of that defines the position of identical and identically oriented details in series, a_2 - vector of that defines the position of equally oriented details in adjacent rows, q - vector of shift grid (figure 2). As the mathematical model of layout is rectangular grid, the vectors a_1 and a_2 are mutually perpendicular.

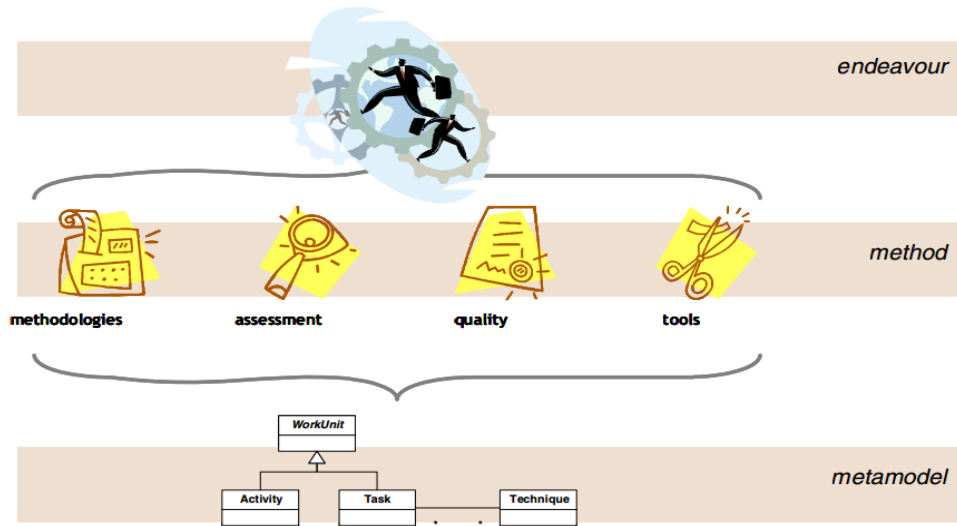


Figure.1 The hierarchical representation of method engineering

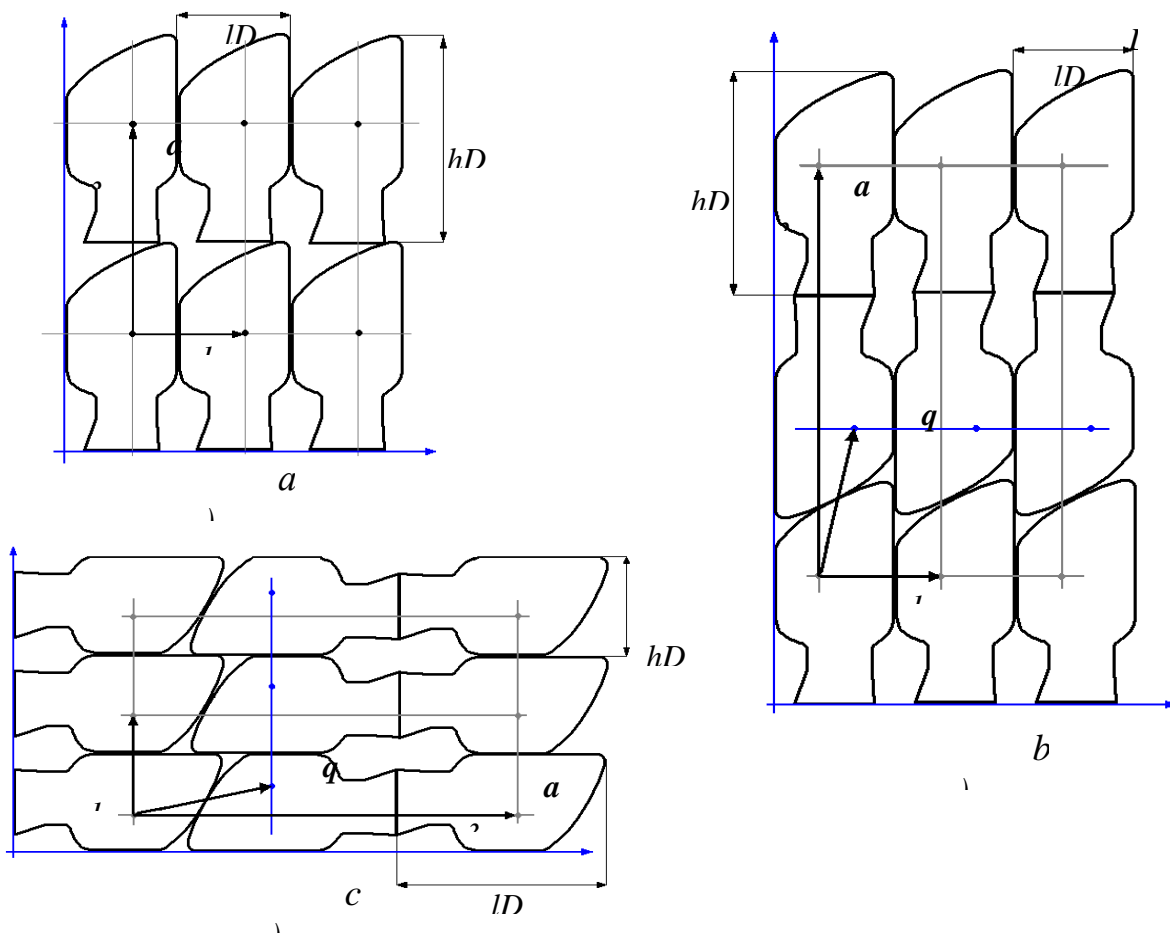


Figure.2. Single and double grids

For a dense combination of the two details along the coordinate axes we shall introduce the

concept of left LB (lower GB), right-RB (upper UB) border of detail.

We shall describe a rectangle around the detail. The borders of detail represented on figure 3. To find the vector of displacement grid - q of double grid W its necessary densely combine the rows of the same parts.

Formulating assessment and quality of problem domain For the illustrating other two components of **method engineering** assessment and quality (figure 1) represent the method of building technological layouts.

To design a set of admissible layouts must do the following items:

- 1 For every detail in set calculate the following parameters single (V) and double (W) laying.

- 2 Choose laying which have the percent of usage material more than given boundary. This layings will be the base for designing the set of admissible layouts.
- 3 For each detail S^k , $k=1,2..q$ of model, generate the set of admissible layouts using the next expressions and limitations:
 - Number of parts should not be more necessary in these parts, ie $i_0, j_0=1,2...i_k \leq R \cdot \check{N}^i$ and $i_0 \cdot j_0 \leq R \cdot \check{N}^k$;
 - Width ShR and length DIR of layout should not be more than appropriate for the width Sh and length (DI) of material is $DIR \leq DI$ and $ShRC \leq Sh$;
 - Density of layout P_r shouldn't be less than the specified density P , ie $P_r \geq P$.

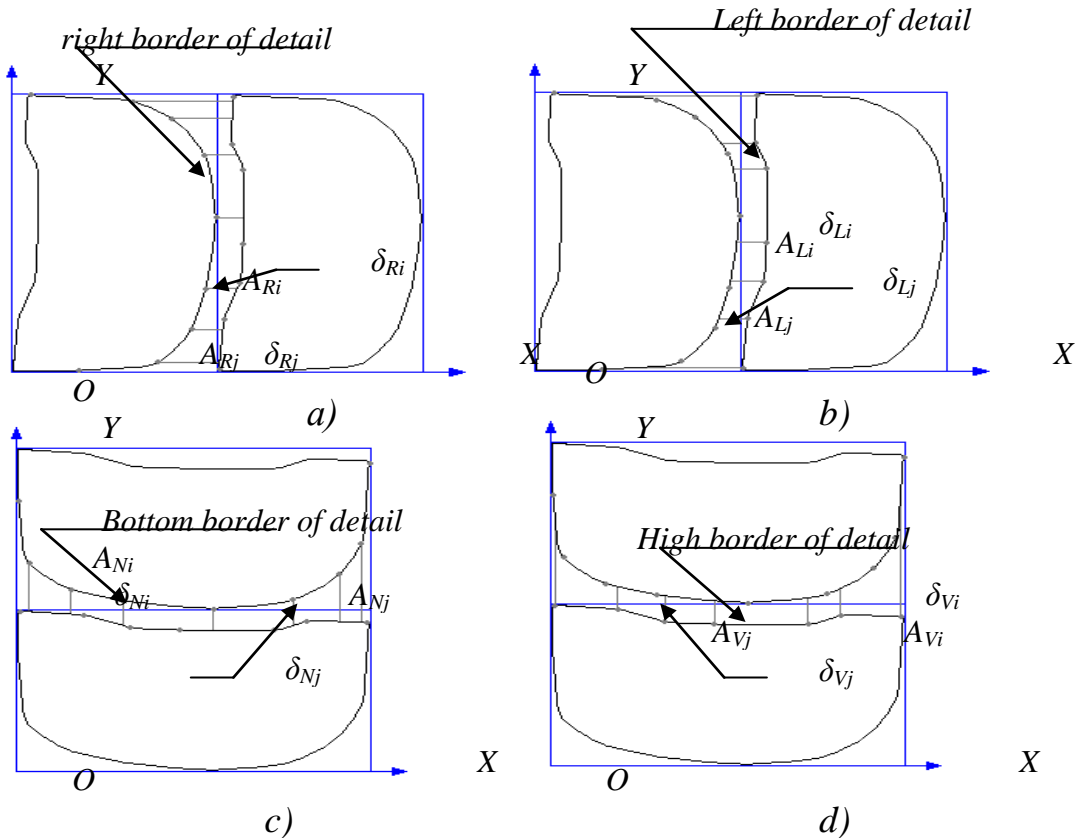


Figure. 3 Dense combination of two details

Knowing coordinates of vectors in a grid define number of details in layout:

$$Xp_{ij} = H(\pi) + (j-1) \cdot a_{1x} + ((i+1)div2) \cdot a_{2x} + ((i+1) mod 2) \cdot q_x$$

$$Yp_{ij} = H(3\pi/2) + (j-1) \cdot a_{1y} + ((i+1)div2) \cdot a_{2y} + ((i+1) mod 2) \cdot q_y$$

where $i = 1,2 \dots i_0$, $j = 1,2 \dots j_0$ and $i_0 \cdot j_0 \leq Q \cdot R$ ($Q \cdot R$ – number of details in layout); H – base function.

The density P_r of layout is defining by the statement:

$$P_r = \check{N}_r \cdot |S^k| / (DI_r \cdot Sh_r) \quad (1).$$

As compact domain was chosen the collaboration diagram can illustrate the process of cutting scheme building. Such a diagram represented on the figure 4.

The diagram, obtained after problem domain research, can be used for refinement

PIM model of problem domain [11].

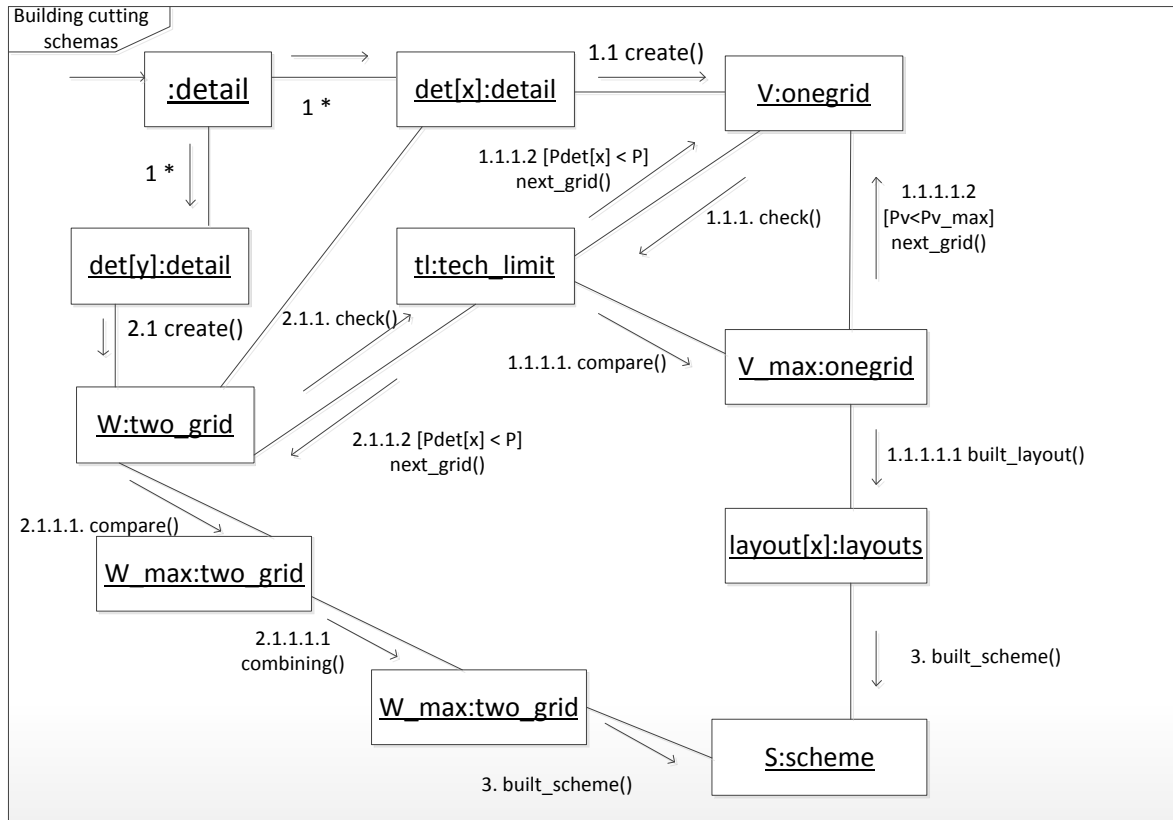


Figure. 4. Collaboration diagram of building cutting schemas, based on layouts both for shoe details and leather goods details

Let’s explore differences between two considering domains.

Task and entities of two chosen subdomains, namely “constructing of laying for shoe details” and “constructing of laying for leather goods details” are the same, namely to construct laying, which has high density and meet technological limits. But the way of solving the task “finding the best laying” is different for each subdomain.

Consider the peculiarities of finding the best laying for the problem domain “designing cutting schemas for leather good details”. The task of defining the best layout for the two subdomains is formulated by following: to find a rectangle double grid W for detail S with $W: na_1 + ma_2 + kg$ which has the highest coefficient of density. The length of layout shouldn’t be more or equal than Sh , and the height shouldn’t be more or equal than Dl , the layouts’ density should satisfy the condition: $P_r \geq P$, where P is border density. Layouts, which have

densities more than P are considered for building cutting schemas.

Constricting of laying for leather goods details

The combination of details is based on linear effects. It’s necessary to find linear effects by height and width of details. Linear effects by height are defining by combination of LB and RG borders of details [11]. It’s effectively when external borders of details are close to rectangles. The idea of finding linear effects by height and width is represented on figures 5 and 6.

Than the lengths of the vector a_1 is corrected by the max value of L_i by height.

The note: if detail is rotated on angle 180 by axis X it’s considered as detail of the second type. On the figures 3 b) and c) details of two different types are combined together

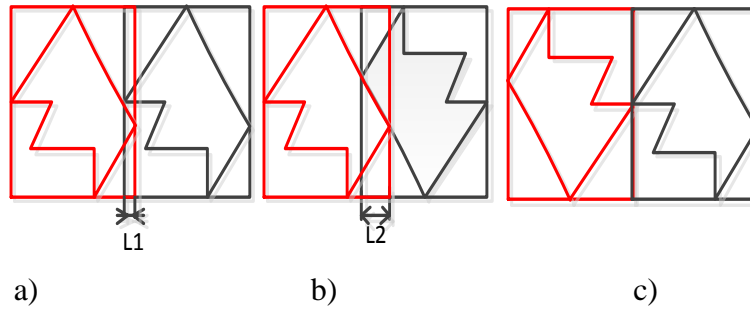


Figure 5. The meanings of linear effects when different borders of the figure are combining together

In order to define the value of vector a_2 in laying the linear effects by width for row are detecting.

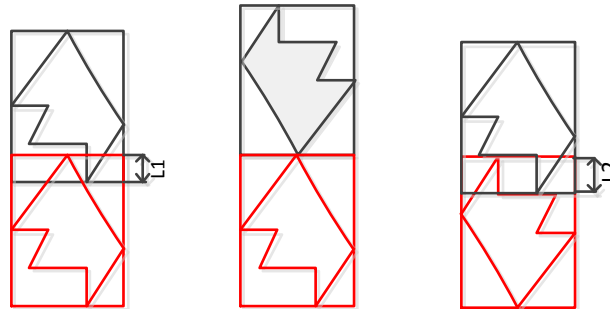


Figure 6. The meanings of linear effects when different borders of the figure are combining together
The value of vector a_2 is corrected on the proper value (L_2 from figure 6).

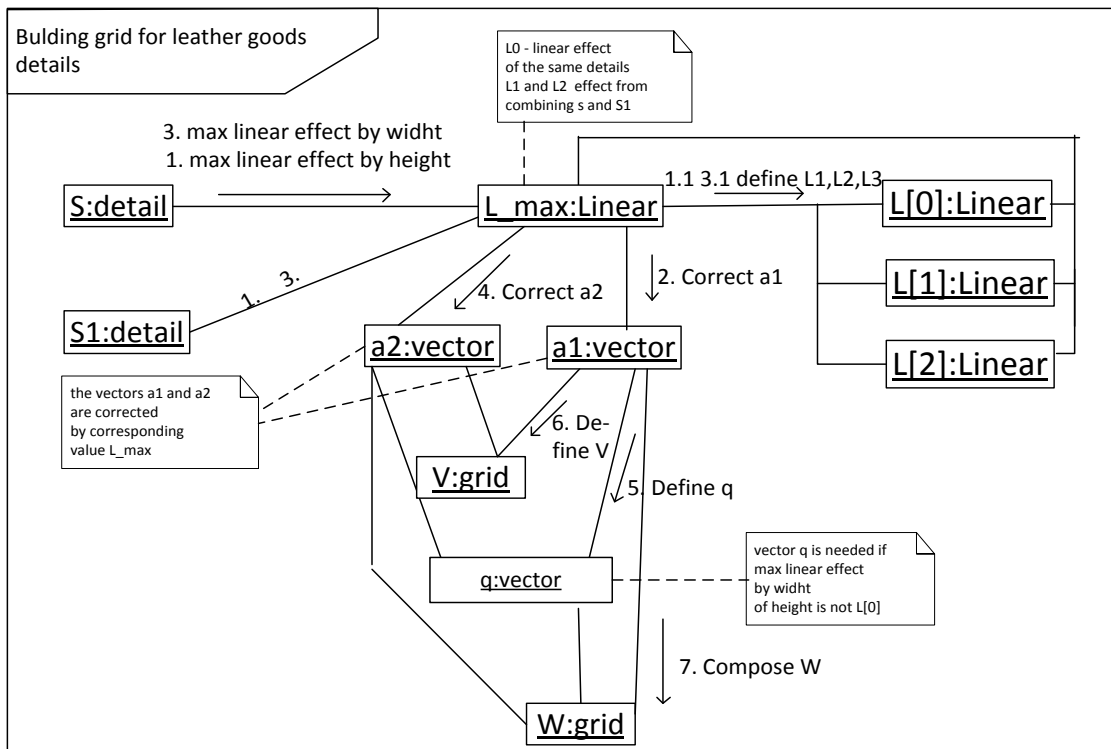


Figure 7. The collaboration diagram of building laying for leather good details

Then, if the best laying, according to (2), is constructed, when the same details are combining, one can use single grid $V = \{\overline{a_1}, \overline{a_2}\}$ in order to build layout. If the best linear effect is archived when

details of different types are combined together the double layout $W = \{\overline{a_1}, \overline{a_2}, \overline{g}\}$

Constricting of laying for shoes details

When the layout for shoe details is build, the other mechanism is used, namely hodograph of the

vector function dense placement [11].

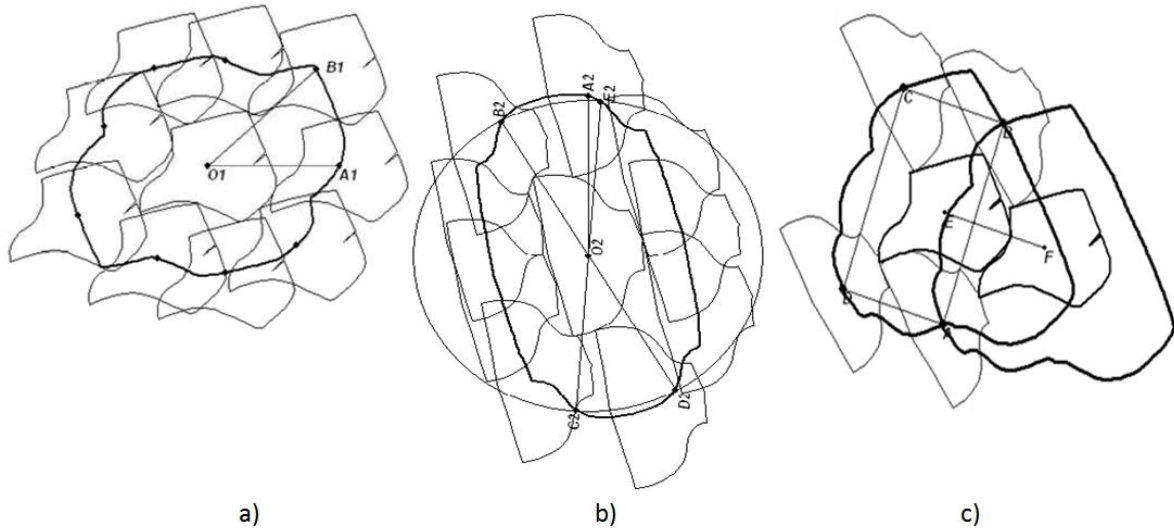


Figure 8. The stages of defining double grid parameters

The hodograph of the vector function dense placement is built for two details (figure 8) for one and another type of detail with themselves. The first figure is a source for defining angle α for details of the first type. The second is the source for defining of the angle β for details of the second type.

When base layout is obtained in order to find the best layout for the constructing of schema it's necessary to do following:

1. The coefficient of density is defined when parameters of single V and double laying W are calculated. Rows are placed among OX and OY axes.

2. For every detail (pair of details) a set of laying is defined, which have coefficient of material usage more than P. This laying are the sources for the sections

Every laying from obtained set contains the next information:

- The length DID and width ShD of the layout;
- the number of rows among OX axis and rows Mrkt among OY axis in layout;
- the characteristics of rows location P (P=true, if rows with the same orientation of details are located among of the axis OX, P = false, if this rows are located among of the axis OY);

- vectors of grid $a_1 * k = \{Xa_1 * k, Ya_1 * k\}$,
 $a_2 * k = \{Xa_2 * k, Ya_2 * k\}$, and $q * k = \{Xq * k, Yq * k\}$;

The length and height of layout is defining by following:

- when rows are located among the OX axis

$$\begin{aligned} DIR &= \max(Xp_{1j_0} + DID; Xp_{2j_0} + DID + q_x) \\ ShR &= i_0 \cdot ShD - (i_0 \text{ div } 2)(\delta r_{12} + \delta r_{23}) + ((i_0 + 1) \text{ mod } 2) \cdot \delta r_{23}, \end{aligned} \quad (2)$$

where $\delta r_{12}(\delta r_{23})$ - is the value of shift seconds (thirds) row

- when rows are located among the OY axis

$$\begin{aligned} ShR &= \max(Yp_{1j_0} + ShD; Yp_{2j_0} + ShD + q_y) \\ DIR &= i_0 \cdot DID - (i_0 \text{ div } 2)(\delta r_{12} + \delta r_{23}) + ((i_0 + 1) \text{ mod } 2) \cdot \delta r_{23}, \end{aligned} \quad (3)$$

where $i \text{ mod } 2$ - the rest of integer division on 2 and $i \text{ div } 2$ - the whole part from division on 2.

For every $i = 1, 2, \dots, i_r \leq R \cdot \check{N}_k$ the value $j_0 = (Q \cdot R) \text{ div } i_0$ is defined.

4. From the set of layout defined those which has the highest percent of material usage.

$$P_{-r} = \frac{i_0 \cdot j_0 \cdot |S|}{DIR \cdot ShR} \quad (4)$$

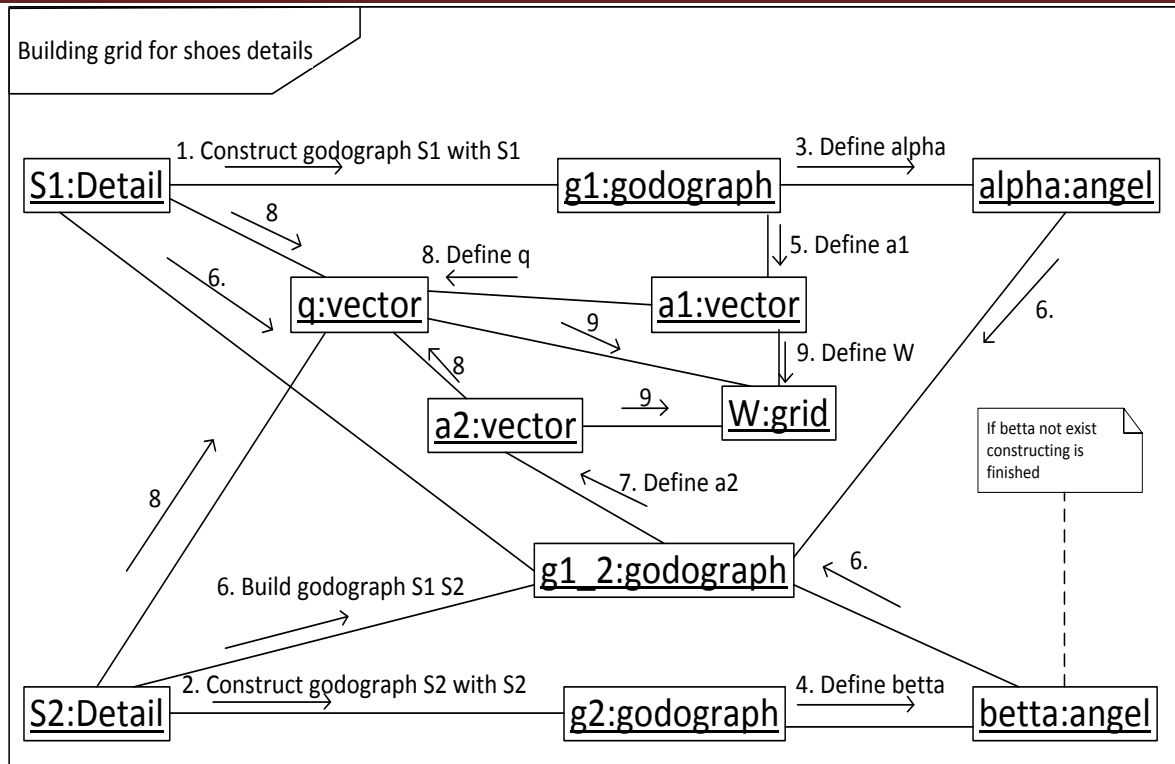


Figure 9. The collaboration diagram of building laying for shoe details

Then, the two details of the first type are tightly aligned by angle α . Two details of the second type are tightly aligned by angle β . Around every detail of the first type the hodograph of the vector function dense placement is built by means of rotation of the detail of the second type around the detail of the first type.

According to the algorithm, proposed in [10] the collaboration diagram will look as it is represented on figure 9.

Conclusions

Researches made in this work let represent the metamodel of problem domain- “building cutting schemas with the layouts” and underline the peculiarities of two subdomains “constructing layouts for leather good details” and “constricting layouts of shoe details”. Also the conditions – satisfy technological limits and of set output were met.

Memamodel was constructed according to demands of modern standards. Estimation of metamodel in correspondence with ISO/IEC 24744 shows, that:

- collaboration diagram can serve both function process for describing the details of the process kinds used in a method and action diagram for showing the detailed usage interactions between task kinds and work product kinds

- it can be used for improvement of PIM-model, obtained in [11].
- analyzing the sequence of actions it’s possible to use built collaboration diagram like model, showing the object lifecycle.
- analyzing the math model one can focus on endeavor.

While analysis built metamodel according to demands of BPDM, implemented in collaboration diagram, it’s interesting to notice, that proposal metamodel correspond choreography approach, as it can serve for showing how does the semi-independent and collaborating entities work together in a process, each of which may have their own internal processes.

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Чебанюк Олена Вікторівна кандидат технічних наук, доцент кафедри інженерії програмного забезпечення факультету комп'ютерних наук Національного авіаційного університету.

Наукові інтереси: методи інженерії програмного забезпечення, технології повторного використання коду, доменна інженерія, технології побудови розкрійних схем.

E_mail chebanyuk.elena@gmail.com



Чупринка Віктор Іванович доктор технічних наук, професор кафедри інформаційних технологій проектування факультету технологій легкої промисловості Київського національного університету технологій та дизайну.

Наукові інтереси: математичні моделі та методи розкрійних технологій, математичні аспекти комп'ютерної графіки, передові технології побудови розкрійних схем та розкрійного виробництва, інженерія програмного забезпечення

E_mail chuprinka_v_i@ukr.net

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