Using Computer Vision and Fuzzy Logic to Assess Quality of Business Process Models

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Використання Комп'ютерного Бачення та Нечіткої Логіки для Оцінки Якості Моделей Бізнес-Процесів

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***Abstract*—In this paper we propose a method for quality assessment of business process models using computer vision and fuzzy logic. OpenCV library usage as well as bypassing of its drawbacks of template matching is considered. Membership functions of metrics of the business process model quality are outlined. Obtained results and future research are discussed.**

***Анотація*—В даній роботі пропонується метод оцінки якості моделей бізнес-процесів на основі комп'ютерного бачення та нечіткої логіки. Розглянуто використання бібліотеки OpenCV та обхід її недоліків щодо пошуку за шаблоном. Наведено функції належності метрик якості моделей бізнес-процесів. Описано отримані результати та напрямки подальших досліджень.**

Keywords—business process model, quality assessment, computer vision, fuzzy logic

Ключові слова—модель бізнес-процесу, оцінка якості, комп'ютерне бачення, нечітка логіка

I. Introduction

Business Process Management (BPM) is one of the most popular management techniques. BPM includes methods and tools for design, analysis, and improvement of organizational activities. Business process is considered as a structured set of tasks that takes one or more kinds of input and produces a product or a service valuable for a specific customer [1]. The fundamental technique of BPM is process modeling, so it is required to design such business process models that can be easily understood by process performers, analysts, managers, and stakeholders [2].

II. Related Work

A. Goals and Notations of Business Process Modeling

The goals of business process modeling include:

- Understand business processes.
- Document business processes (for instructing people).
- Analyze business processes (to find errors or measure performance)
- Improve business processes described by models.

Event-driven Process Chain (EPC) and Business Process Model and Notation (BPMN) models are the most popular process modeling notations nowadays. EPC business process models are used in the field of business process automation, for example in SAP Reference Model [3]. However, there is no open exchange format for EPC models and the available tool ARIS Express allows to store designed process models only in a form of images or text descriptions, which makes their further analysis extremely complicated.

B. State-of-the-art of Process Model Quality Assessment

Related work on business process model quality is shown in [4]. There are three groups of methods related to business process model quality are demonstrated:

- Process modeling guidelines, such as 7PMG.
- Process model metrics (e.g., the number of nodes S_N, connectors S_C, events S_E, functions S_F, arcs S_A) used to evaluate correctness of analyzed models.
- Threshold values for identified metrics.

III. Proposed Solution

A. Templates of Business Process Model Objects

According to the introduced metrics, it is required to use the templates (see Fig. 1) of connectors of all possible types (XOR, OR, AND), events, functions, and arcs (that income from left, right, top, and bottom of an object).

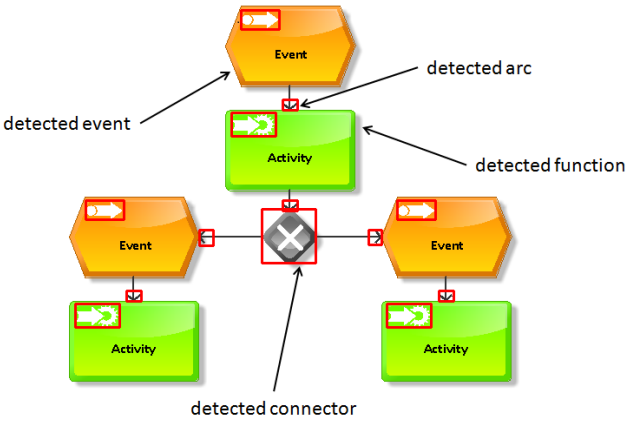

Fig. 1. Templates of detected objects

Open-source computer vision library OpenCV is used to detect objects required to calculate process model metrics on a business process diagram.

B. Overcoming Drawbacks of OpenCV Template Matching

The template matching algorithm of OpenCV library has the drawback related to multiple detected objects around the actual single object on the image. In order to define correct values of the business process model metrics it is required to combine such close matches.

For this purpose the Euclidean distance might be used to merge close points that represent detected objects:

$$d(p,q)=\sqrt{\sum_{i=1}^{n}(p_i-q_i)^2}. \quad (1)$$

Here p and q are 2D space points that describe the same object on the business process diagram, which was detected by the OpenCV template matching algorithm.

The following procedure is proposed in order to bypass possible collisions of detected objects (Fig. 2).

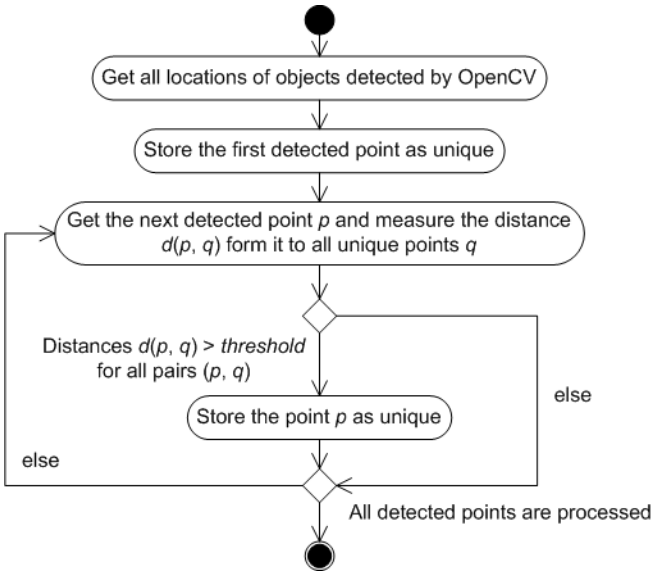

Fig. 2. Procedure of possible collisions bypassing

C. Applying Fuzzy Logic to Assess Process Model Quality

We can provide $m = 5$ process model metrics in a form of the following tuple (S_N, S_C, S_E, S_F, S_A), as well as respective threshold values – (48, 8, 22, 40, 62). Therefore, by applying fuzzy logic ideas, we can define the following membership function for each of the j-th business process metric:

$$\forall j=\overline{1,m}:\mu_j(x)=\begin{cases}\dfrac{x}{a}, x\le a;\\ 1, x>a.\end{cases} \quad (2)$$

Here x is the value of j-th metric of the business process model quality and a is the threshold value of the j-th metric. These functions show degrees of truth that metrics overstep the corresponding thresholds, which indicates possible errors in a business process model. Since the all thresholds should not be overstepped to ensure the quality of a business process model, the intersection operation is applied:

$$hasErrors=\min_{j=1,m}\{\mu_j(x)\}. \quad (3)$$

IV. Research Results

Developed Python application that implements proposed solution was used to perform calculations. EPC diagrams of goods receipt and software development business processes were analyzed (see Tab. 1) [5].

Obtained results of quality assessment demonstrate that business process models of high complexity are more error-prone than business process models of low complexity:

- "diagram106.jpeg" – $S_N = 31$, $S_C = 6$, $S_E = 16$, $S_F = 9$, $S_A = 51$, $hasErrors = 0.82$;
- "diagram107.jpeg" – $S_N = 7$, $S_C = 9$, $S_E = 4$, $S_F = 3$, $S_A = 10$, $hasErrors = 0.18$.

Conclusion

Quality of small process models is always higher than of large models because of human ability to concentrate only on a limited number of objects. Hence, further work in the field of business process model quality is relevant and should be focused on quality improvement methods and tools as well.

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