Attributed Graph Matching Based Line Drawings Retrieval

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***Abstract* — Online maintenance of large volume document data such as Engineering drawings is very difficult. It is very common thing for Engineers and Designers to get some information from Engineering drawings which is generally slow and tedious process. This paper presents a method for line drawings retrieval from Engineering Drawings by their shape appearance, topological relations and contour properties. In this method line drawing is represented by an attributed graph (N-way tree), where each node corresponds to some meaningful properties of contour. The drawing retrieval is formulated as attributed graph matching. Inexact graph matching algorithms are inherently an NP-hard problem with exponential complexity. It is the aim of the proposed algorithm to reduce the complexity of the inexact graph matching process, while still producing an optimal solution for a known application. This is achieved by greatly simplifying graph to N-way tree data structure and compensating loss of robustness by hierarchy of matching process. The proposed algorithm is translation, rotation and scale invariant of given drawing image. Results show that proposed algorithm is accurate and fast in terms of shape matching of line drawings, and show promise for the application of shape matching.**

Keywords — Graph Matching, Shape Matching, Line Drawings, N-way Tree, Attributed Graph, Image Contours, Topological Structure, Engineering Drawings

I. INTRODUCTION (MOTIVATION & HISTORY)

For any architectural project, many multi-dimensional drawing documents are made and printed on large sheets. A big project contains many such drawing documents and the number increases continuously as the project grows. Architectural drawings need utmost attention to details; so that contribution can be flawless when the scale of project is very large it is impossible to fit the whole project in a single drawing document sheet even if the size of sheet is very big. In such cases, it becomes necessary to assign a symbolic object representation to some sections of a drawing. This eases the task of the architect to detect and identify objects and their functionality and purpose. These objects were printed all over project where ever it is necessary. Online maintenance of such large volume Engineering Drawings documents has become a major research area related to automatic Engineering Drawing interpretation. It is very common thing for designers and draft people to get some information. However, retrieving these documents generally is a slow & tedious work. To facilitate such retrieval, textual content such as keywords has been widely used which is a heavy work to generate such descriptions manually and also sometimes incapable of describing the true content in a drawing. There is almost no developed mechanism that supports automated drawing retrieval system to ease the drawing retrieval process. To ease this process of fetching we developed a new system to support automatic classification and retrieval of Engineering drawings based on their shape appearance, topological relations and contour properties, rather than relying solely on textual annotations or metadata.

Several works have been reported in the literature regarding image retrieval based on its content. In the work [attr grp], the drawings are first represented by attributed graphs, where graph nodes correspond to meaningful primitives extracted from the original drawing image, such as lines and curves, while the spatial relationships between these primitives are described by graph edges. The primitives generation is process of decomposing intersection points obtained from thinning drawing to single pixel width and then, a merge-split process is used to make them more meaningful. The primitives obtained from above process are treated as nodes of attributed graph and the Delaunay tessellation strategy is used to generate the structural description of engineering drawings. The problem of graph matching is solved using mean field theory. In the work [2d & 3D], the authors proposed algorithm of matching a 2D Engineering Drawing and 3D model for process plant. It is a topological structure based algorithm which based on the property of any 3D model and 2D engineering drawing have similar topologies if they are derived from the same process plant. A typical process plant 3D model mainly consists of thousands of basic components, including equipment, pipelines (i.e. pipes and piping components), valves, instruments, etc. Components are comprised of fourteen basic entities such as cylinder, scylinder, prism, cone, concone, squcir, squcone, box, torus, squtorus, sphere, wedge, saddle and oval. Contents in 2D drawing field are the set of component shapes, dimensions and projecting direction indicators. The proposed method consists of two primary steps: (1) preprocessing is applied to 3D model and 2D Engineering drawing to transform into attributed graphs; (2) methods to find similarity between two graphs. The preprocessing step of 3D model into attributed graph setups the components in the model as nodes of graph, type and insertion coordinate as nodes attributes and topological relations as edges.

The preprocessing step of 2D drawing follows same as 3D like components as nodes and topological relations as edges but it additionally does the filtering of annotations and illustrations. The problem of graph similarity is solved using Max-Common sub graph and Min Edit Distance methods.

The remaining of this paper is arranged as follows: In section 2, we describe the engineering drawing decomposition process to convert the drawing image into attributed graph using image contours. In section 3, graph matching algorithm is outlined. At last, the experiments as well as some discussion are given in section 5.

II. Architecture

A. Selecting a Template (Heading 2)

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A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations su

ch as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in

$$a + b = \gamma \qquad (1)$$

$$\alpha + \beta = \chi. \qquad (1)$$

(1) (1)

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is ..."

D. Some Common Mistakes

- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o."
- In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside

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- A graph within a graph is an “inset,” not an “insert.” The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
- Do not use the word “essentially” to mean “approximately” or “effectively.”
- In your paper title, if the words “that uses” can accurately replace the word using, capitalize the “u”; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones “affect” and “effect,” “complement” and “compliment,” “discreet” and “discrete,” “principal” and “principle.”
- Do not confuse “imply” and “infer.”
- The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the “et” in the Latin abbreviation “et al.”
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An excellent style manual for science writers is [7].

IV. Graph Construction

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Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include ACKNOWLEDGMENTS and REFERENCES, and for these, the correct style to use is “Heading 5.” Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract,” will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named “Heading 1,” “Heading 2,” “Heading 3,” and “Heading 4” are prescribed.

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1) Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1,” even at the beginning of a sentence.

TABLE I. Table Styles

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		

a. Sample of a Table footnote. *(Table footnote)*

b.

Fig. 1. Example of a figure caption. *(figure caption)*

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity "Magnetization," or "Magnetization, M," not just "M." If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization (A (m(1)," not just "A/m." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

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REFERENCES

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Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

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To have non-visible rules on your frame, use the MSWord "Format" pull-down menu, select Text Box > Colors and Lines to choose No Fill and No Line.

[1] G. Eason, B. Noble, and I.N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (*references*)

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[3] I.S. Jacobs and C.P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.

[4] K. Elissa, "Title of paper if known," unpublished.

[5] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.