Final Report of GREC'13 Arc and Line Segmentation Contest

Syed Saqib Bukhari[1], Hasan S.M. Al-Khaffaf[2(✉)], Faisal Shafait[3], Mohd Azam Osman[4], Abdullah Zawawi Talib[4], and Thomas M. Breuel[1]

[1] Technical University of Kaiserslautern, Kaiserslautern, Germany
{bukhari,tmb}@informatik.uni-kl.de
[2] University of Duhok, Kurdistan Region, Iraq
hasan.salim@uod.ac
[3] The University of Western Australia, Perth, Australia
faisal.shafait@uwa.edu.au
[4] Universiti Sains Malaysia, Georgetown, Malaysia
{azam,azht}@cs.usm.my

Abstract. Recognition of geometric primitives such as line and arc helps in automatic conversion of line drawing document images into electronic form. A large number of raster to vector methods can be found in the literature. A line and arc segmentation contest was held in conjunction with the tenth IAPR International Workshop on Graphics Recognition (GREC 2013) for comparing performance of different methods on a uniform platform. The contest was broken down into two challenges: arc segmentation and line segmentation. The dataset includes engineering drawings (for arc segmentation challenge) and cadastral maps (for line segmentation challenge). Jianping Wu's method got the highest score (0.541), hence the winner of the Arc Segmentation Contest. Liu Wenyin's method, the only method participated in the line segmentation contest achieved 66 % segmentation accuracy.

Keywords: Graphics recognition · Line drawing · Arc and line segmentation contest · Performance evaluation

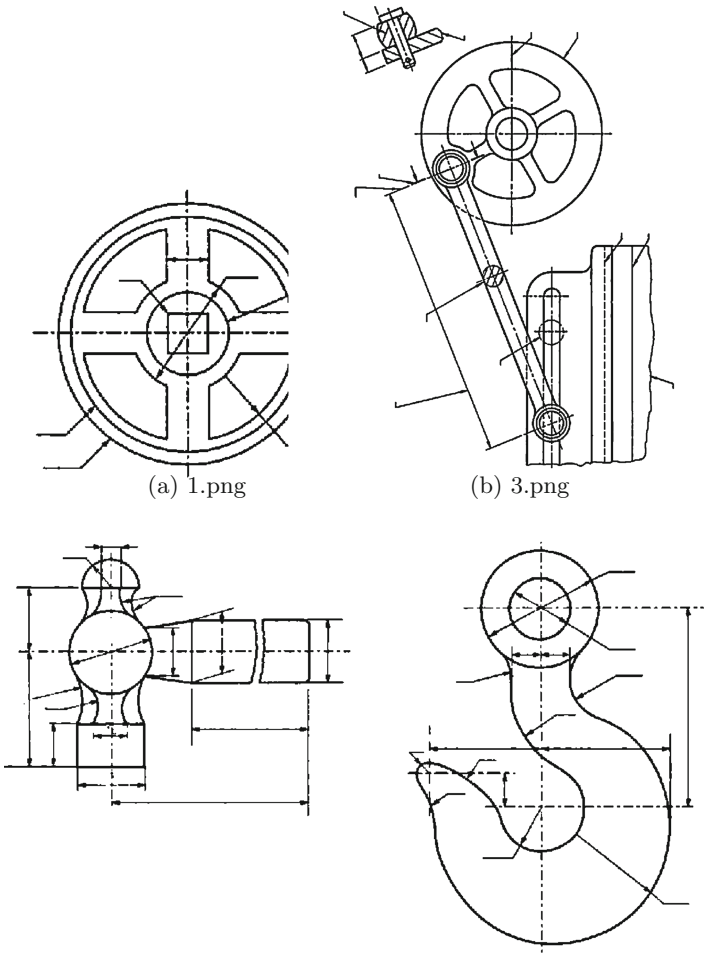
1 Introduction

This paper summarizes the outcomes of the Arc and Line Segmentation contest 2013 that was held in conjunction with the Tenth IAPR International Workshop on Graphics RECognition (GREC) held in Lehigh University, Bethlehem, PA, in August 2013. In this edition of the contest, two challenges were available for the contestants: arc segmentation and line segmentation of engineering drawings and cadastral maps respectively. The images were selected from a text book and from Internet. The output of research prototypes as well as commercial software were acceptable.

B. Lamiroy and J.-M. Ogier (Eds.): GREC 2013, LNCS 8746, pp. 234–239, 2014.
DOI: 10.1007/978-3-662-44854-0_18

2 Test Images, Ground Truthing, and Expected Vectors

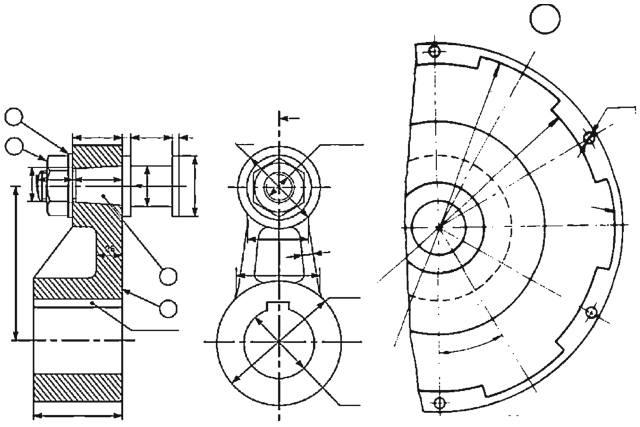
For the arc segmentation contest challenge, eight binary images were selected from a text book and the Internet (Fig. 1). Manual editing using a raster image editor is used to remove all text annotations from the drawings leaving only graphical elements. A vector editor was manually used to recreate the mechanical parts by drawing the vectors on the top of the raster image. Contextual knowledge was used to align the graphical elements with each other such as co-centered arcs/circles. Line width information is not supported in this dataset. The width field of the graphical elements is set to the value of 1.



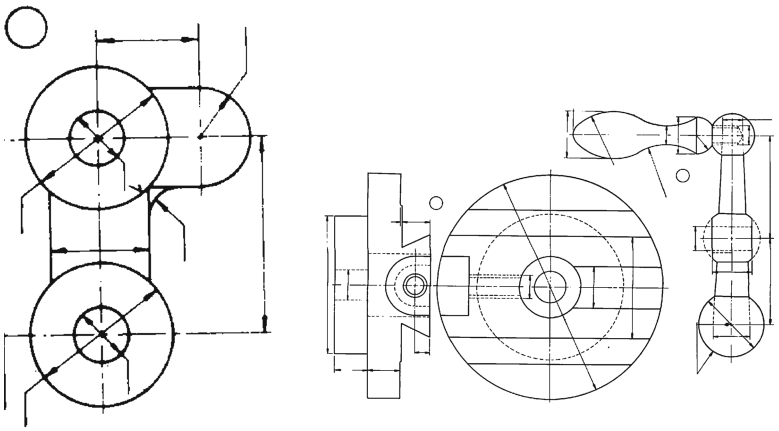
(a) 1.png (b) 3.png

(c) 2.png

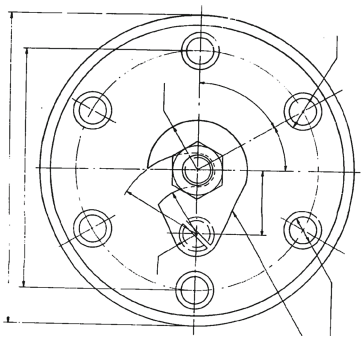
Fig. 1. Test images for the arc segmentation challenge



(d) 4.png (e) P216A.png



(f) P216C.png (g) P227.png



(h) P247.png

Fig. 1. (*continued*)

As its name implied, the arc segmentation challenge involve only arcs and circles. Other graphical elements such as straight lines and text were ignored. Dashed circles/arcs entities were vectorised in a different way. Each part of the dashed arc/circle was vectorized as a standalone arc with its own center, radius, starting and ending angles.

For the line segmentation contest challenge, four cadastral maps, that are captured from record rooms and gathered from the Internet, were used. The sample images are shown in Fig. 2. Altogether, these images contain both non-broken and broken types of lines, where broken lines occur due to image degradations. The annotations/texts were removed from the sample images. The ground-truth was marked using pixel-accurate color-coding of page segmentation as presented in [1] and was also used in GREC 2007 Arc Segmentation Contest [2]. The ground-truthed images are shown in Fig. 2 These sample images were used for both training and testing.

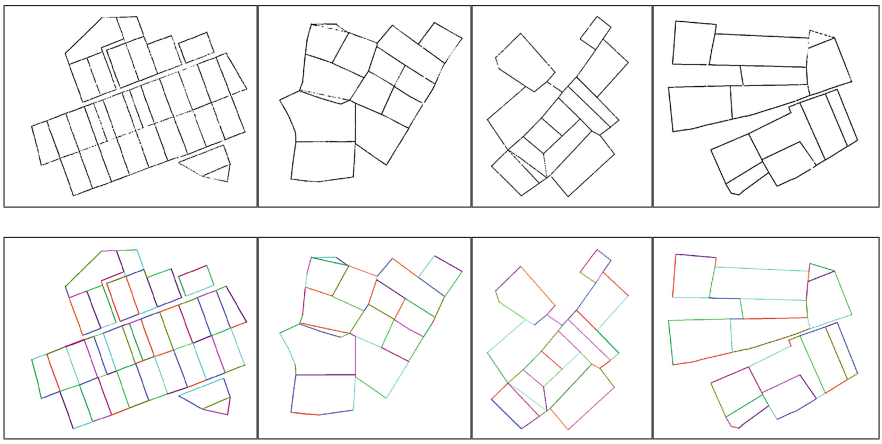


Fig. 2. [Top-Row] Training and testing (cadastral map) images for line segmentation contest challenge. [Bottom-Row] Pixel-accurate color-coding ground-truthed.

A webpage[1] holding the test/train images is available for interested parties.

3 Participated Methods

Three participants (Table 1) for Arc Segmentation Contest provided the output of their research methods. One of the participants, Liu [3], also submitted the results for line segmentation contest challenge.

[1] https://sites.google.com/a/iupr.com/grec2013_arc_and_line_seg_contest/

Table 1. Participated methods for arc and line segmentation contest

Vectorizer	Author(s)	Affiliation
Liu's method$^{A\&L}$ [3]	Liu Wenyin	Department of Computer Science, City University of Hong Kong, Hong Kong, China
Qgar-Lamiroy^{A} [4]	Bart Lamiroy	Université de Lorraine, LORIA, Nancy, France
FACILE^{A} V2.1 [5]	Jianping Wu	School of Computer Engineering, Suzhou Vocational University, Suzhou, China

$^{A\&L}$ participation in arc and line challenges, ^{A} arc challenge only

Table 2. Arc challenge performance scores [D_v, F_v, VRI] for the participated methods

Image	Liu's	Qgar-Lamiroy	FACILE
1.tiff	[.022, .947, **.034**[a]]	[.107, .758, .161]	[.111, .758, .164]
2.tiff	[.375, .554, .409]	[.591, .450, **.570**]	[.651, .599, .511]
3.tiff	[.109, .923, .092]	[.301, .818, .234]	[.512, .718, **.380**]
4.tiff	[.676, .329, .674]	[.940, .213, .860]	[.858, .109, **.875**]
P216A.tiff	[.320, .716, .301]	[.431, .692, .364]	[.852, .483, **.664**]
P216C.tiff	[.871, .128, .871]	[.936, .080, **.928**]	[.977, .128, .923]
P227.tiff	[.432, .669, **.378**]	[.111, .905, .103]	[.199, .889, .149]
P247.tiff	[.152, .866, .143]	[.074, .955, .058]	[.852, .483, **.664**]
Avg	0.363	0.410	**0.541**

[a]Highest VRI scores are shown in bold

4 Performance Evaluation Method

For arc segmentation contest challenge, Vector Recovery Index (VRI) score [6] was used in this contest as performance criterion for the three contested methods.

$$VRI = \sqrt{D_v * (1 - F_v)} \tag{1}$$

where D_v is the detection rate and F_v is the false alarm rate. The VRI in the range [0..1] is the overall score used to select the winner of arc segmentation contest. The higher VRI value, the better recognition we have.

For line segmentation contest challenge, the vectorial score proposed in [1] is used for the performance evaluation. Together with one-to-one segmentation accuracy, the vectorial score also reports over-segmentation, under-segmentation, and missed-segment failures. The ground-truthed images are marked here in more details where we consider two or more collinear adjacent line segments as different lines. However, the challenge is line segmentation contest, not line segment detection. Therefore we consider under-segmentations also as correct detection, and the line segmentation accuracy is the summation of one-to-one accuracy and under-segmentations.

5 Results and Discussion

FACILE method gets the highest VRI scores on 4 out of 8 test images (Table 2) and an average VRI score of 0.541, hence the winner of the this edition of the arc segmentation challenge.

For line segmentation challenge, the test dataset contains total 244 lines. Liu's method reported 585 lines, out of which 161 are correctly detected lines, 112 over-segmentation failures, and 1 missed-segment failure. Liu's method achieved 66 % of line segmentation accuracy.

Acknowledgment. The authors would like to thank Abdul Halim Ghazali for his efforts in preparing the ground truth images for the arc segmentation challenge.

References

1. Shafait, F., Keysers, D., Breuel, T.M.: Pixel-accurate representation and evaluation of page segmentation in document images. In: Proceedings of the 18th International Conference on Pattern Recognition, Hong Kong, China, vol. 1, pp. 872–875 (2006)
2. Shafait, F., Keysers, D., Breuel, T.M.: GREC 2007 arc segmentation contest: evaluation of four participating algorithms. In: Liu, W., Lladós, J., Ogier, J.-M. (eds.) GREC 2007. LNCS, vol. 5046, pp. 310–320. Springer, Heidelberg (2008)
3. Liu, W.Y., Dori, D.: Incremental arc segmentation algorithm and its evaluation. IEEE Trans. Pattern Anal. Mach. Intell. **20**(4), 424–431 (1998)
4. Lamiroy, B., Guebbas, Y.: Robust and precise circular arc detection. In: Ogier, J.-M., Liu, W., Lladós, J. (eds.) GREC 2009. LNCS, vol. 6020, pp. 49–60. Springer, Heidelberg (2010)
5. Wu, J., Chen, K., Gao, X.: Fast and accurate circle detection using gradient-direction-based segmentation. J. Opt. Soc. Am. A **30**(6), 1184–1192 (2013)
6. Liu, W.Y., Dori, D.: A protocol for performance evaluation of line detection algorithms. Mach. Vis. Appl. **9**(5–6), 240–250 (1997)