Proposed method for scale drawing calculating depending on the line detector and length detector

Huda Dheyauldeen Najeeb^{1,*}, Rana Fareed Ghani²

¹Department of Public Relations, University of Al Iraqia, Baghdad, Iraq.

²Department of Computer Science, University of Technology, Baghdad, Iraq

*Corresponding Author: Huda Dheyauldeen Najeeb

DOI: <https://doi.org/10.52866/ijcsm.2021.02.02.002>

Received February 2021; Accepted May 2021; Available online July 2021

ABSTRACT: A scale drawing is a significant tool in many fields such as geography, mathematics, and astronomy research as it has a variety of applications, including Google maps. A new way to benefit from the scale drawing in soccer image is presented in this paper. When the distance of the camera is uncertain, the scale drawing can be used to determine the relationship between the ball and players to estimate the ball size and determine the zooms in and out.

The scale drawing and factor are used in architecture and image processing. After calculating the scale factor, the length of every part or line in the image can be computed by multiplying the original length by the scale factor. The research findings indicated that the proposed work was successful in computing the scale drawing in two ways, namely, line detector and length detector, with approximate results to the desired results.

Keywords: Scale drawing; Factor drawing; Soccer court; Shape representation; Contour methods

1. INTRODUCTION

A scale drawing is a clarification of something that is drawn either smaller or larger than the original. For example, a scale drawing of a building is drawn smaller than the original drawing, but on the same scale. Scale drawing is a valuable tool for any designer because it can be used to adjust landscape plans, visualize, and plan before breaking ground. As compared with the real objects, scale drawings allocate each object to the same scale [1] [2].

Several research have emerged in this subject area. Chuck et al. [3] determined the relationship between the moon and earth using scale drawing to draw them on paper. The scale drawing was measured to determine the diameter in paper based on the real diameter of the moon and earth. The research discovered that scale drawings result in a 1/4 scale, thus if the diameter of the earth in the paper is eight, the diameter of the moon in the paper is 2. Tanvir et al. [4] used a scale ratio for analyzing the effect of zooming the image size, thus the scale of increased picture does not follow the same equation all time. Xinguo et al. [5] presented a way for estimating the ball size depending on identifying a set of salient objects in the court to their physical sizes (such as the center circle or goalmouth) to detect and track the ball in broadcasting soccer videos. Thereafter, the ball's size is calculated by multiplying the ratio by the ball's physical size.

2. SCALE DRAWING AND SCALE FACTOR

A drawing of an actual thing that has been accurately scaled down or enlarged by a specified quantity (i.e., scale). When comparing the relative magnitudes of huge items, scale drawings are extremely beneficial. A scale model of solar system is frequently shown at science museums to help us understand the vast distances between each planet and the sun.

FIGURE 2. Various Ways for Shape Representation

(a) Using a single point, (b) Using a set of points, (c and d) geometric shapes, (e) Articulated shape, (f) Skeletal model, (g and h) contour representation, and (i) silhouette representation [13]

Algorithm: Proposed method

Input: Video with supporting 30 fps at a Resolution of 1280x960 or any image.

Output: Computing scale drawing

Step 1: Start.

Step 2: IF (Input = Image) Then

Step 3: Call Image Scale Drawing algorithm.

Step 4: Else Call Video Scale Drawing algorithm.

Step 5: End.

Step 6: Image Scale Drawing algorithm.

Step 7: Read image.

Step 8: First method: The object was detected using background subtraction and calculated the length of the object using the contour method.

Step 9: Second method: Detect the lines by performing Hough detection.

Step 10: Finding the scale drawing for each method.

Step 11: Go to Step 5.

Step 12: Video scale drawing algorithm

Step 13: Read video and spilt it into several frames.

Step14: First method: For each frame, the players were detected using background subtraction and calculated the average length of the players using the contour method.

Step15: Second method: Read one frame and for every camera.

Step 16: IF (using camera = camera1) or (using camera = camera3)

Step 17: Detect the lines by performing Hough detection. This algorithm based on the penalty area line. First, the penalty area line is determined using the contour method. Second, calculate its length using the Pythagorean law.

Step 18: Else

Step 19: Detect the center circle by performing Hough detection, then calculate the radius of the circle.

Step 20: Finding the scale drawing for each method.

Step 21: Go to step 5.

6. RESULTS AND DISCUSSION

The computing scale drawing is discussed in this section. A scale drawing is an important tool in image processing to estimate the size of the object in the image to measure the reduction and enlargement ratio of the object. Furthermore, the scale drawing can be used in several games such as soccer, tennis, and basketball to estimate the size of the ball to identify the ball among other objects to track it. Therefore, the proposed system with a predefined scale drawing was applied to the dataset of a soccer game.

6.1 Images with a predefined scale drawing

The scale drawings of three images in Fig. 3, 4, and 5 were computed in this work. First, using the grasshopper image, as shown in Fig. 3. The first image on the top left has been considered the original image because of the scale drawing of 1:1. The drawing scale of the images was calculated based on the length of these images, which were calculated according to the contour method. The result was obtained by dividing the length of each grasshopper image by the length of the original image.

FIGURE 6. Output using a length detector

Second, the soccer court image in Fig. 4 has been used. Using a line detector, a scale drawing of a soccer court was measured, as shown in Fig. 7. Results show that the scale factor = 0.009845 and the scale drawing = 1 cm:101.57 cm.

Third, an image of the Eiffel Tower image in Fig. 5 has been used. Length and line detector methods have been applied to compute the scale drawing in each method.

1) Line detector

Line 1 in the Eiffel Tower is used to calculate the scale drawing for the image.

- The contour method is used to calculate the length of the line 1 in the tower area.
- The real length of line 1 is converted to cm by multiplying 70.69 m with 100.
- The drawing scale is calculated by dividing the length of the line 1 in the picture by its true length.
- The results are as follow:

FIGURE 7. Line detector application on the soccer court

$$\text{Scalefactor} = 0.027157553287$$

$$\text{Scaledrawing} = 1\text{cm} : 36.8221683$$

2) Length detector

The length of the Eiffel Tower is used to calculate the scale drawing for the image.

- The contour method is used to calculate the length of the tower.
- The real average length of the tower is converted to cm by multiplying 324 m with 100.
- The drawing scale is calculated by dividing the length of the Eiffel Tower in the picture by its true length.
- The results are as follow:

$$\text{Scalefactor} = 0.028638196019148$$

$$\text{Averagescaledrawing} = 1\text{cm} : 34.9184005\text{s}$$

The result of all methods calculated an estimated scale drawing with a low error ratio estimated from the equation, thus:

$$\text{Error rate} = |\text{Original image's scale factor} - \text{Proposed method's scale factor}| \quad (2)$$

After calculating the scale factor, the length of every part or line in the image can be computed by multiplying the original length by the scale factor as shown in Table s 1, 2, and 3.

Table 1. Results of the proposed method in the grasshopper image

	Predefine drawing scale	Drawing scale was obtained using a length detector	Predefine scale factor	Scale factor was obtained using a length detector	Error rate
Second image	1:2	1:2.03	0.5	0.498023786	0.00196721
Third image	2:1	2.045:1	2	1.99735519	0.00264481

6.2 Dataset

The proposed system was applied in the soccer game database which was held in 2014 at Alfheim Stadium (Tromsø IL) in Norway. The game was photographed at night using three basler cameras, each of which comprises 941 videos. Each video was made from a single three-second video clip with a resolution of in the (1280 × 960) pixels in H.264

FIGURE 8. Output using a length detector

FIGURE 9. Output using a line detector

Table 2. Results of the proposed method in the soccer court image

	Original Information	Result was obtained by using line detector
Scale drawing	1 cm:100 m	1 cm:101.57 m
Scale factor	0.01	0.0098454
Radius of circle	9.15 cm	9.0085 cm
Error rate		0.0001546

Table 3. Results of the proposed method in the Eiffel Tower image

Original Image yielded the result		The length detector was used to get the result	The line detector was used to get the result.
Scale factor	0.027777	0.028638196	0.0271575532
Length of line1	1.9635 cm	2.02427 cm	1.9197 cm
Length of line2	1.1238 cm	1.1586 cm	1.0987 cm
Length of line3	0.5180 cm	0.5340 cm	0.5064 cm
Height of Tower	8.999 cm	9.27877 cm	8.79886 cm
Error rate		0.00086041824	0.000620224

format [19]. Scale drawing can be computed in two ways, namely, line and length detectors. Line detector is a way for estimating the ball size based on identifying a set of salient objects in the court to their physical sizes such as the radius of the center circle or penalty area, thus can be used in online and offline games. Length detector can be used in offline games only and can be calculated by multiplying the average player's height by their physical height to detect and track the ball in soccer videos. Therefore, this way is used when the salient objects in the court do not appear in the frame.

1) Line detector

Three steps to calculate the scale drawing for camera 1 and camera 3 based on the penalty area line are conducted:

- In both cameras, the Pythagorean law is used to calculate the length of the penalty area line.
- The real length of line is converted to cm by multiplying 44.3 m with 100.
- The drawing scale is calculated by dividing the length of the line in the image by its true length.

While the three steps to calculate the camera 2's scale drawing based on the radius of the court's center circle:

- The contour method in camera 2 is used to calculate the length of the radius of the court's center circle.
- The real length of radius is converted to cm by multiplying 9.15 meters with 100.
- The drawing scale is calculated by dividing the radius of the center circle in the image by its true radius.

FIGURE 10. Line detector application on camera 1

2) Length detector

There are three steps to calculate the scale drawing of all cameras based on the average players' length in multiple frames at each camera:

- In all cameras, the contour method is used to calculate the average players' length.
- The real average players' length is converted to cm by multiplying 1.75 m with 100.
- The drawing scale is calculated by dividing the average players' length in the image by their true length.

FIGURE 11. Line detector application on camera 2

FIGURE 12. Line detector application on camera 3

FIGURE 13. Length detector application on camera 1

The results are as follow: Scale factor = 0.0022603100 with an average scale drawing = 1:442.4171905

FIGURE 14. Length detector application on camera 2

The result are as follow: Scale factor = 0.002644762179261 with scale drawing = 1 cm:378.105830 cm

FIGURE 15. Length detector application on camera 3

The results are as follow: Scale factor = 0.0017427038374 with scale drawing = 1 cm:573.820966 cm

The error rate between the two methods can be calculated using the following equation:

$$\text{Error rate} = | \text{Method 1's scale factor} - \text{Method 2's scale factor} |.$$

Once the scale factor was calculated, the ball's size can be estimated and the length of each part or line in the image can be calculated by multiplying the original length with the scale factor.

Table 4. Summary of the result

Number of the camera	Method 1's scale factor	Method 2's scale factor	Error rate
Camera 1	0.00314807383	0.00226031000	0.00088776383
Camera 2	0.00140983606	0.00264476217	0.00123492611
Camera 3	0.00278869074	0.00174270383	0.00104598690

Table 5. Comparative results with other related works

Name of researcher	Method to calculate scale drawing	Reason for using a scale drawing
Chuck and others	pen and ruler	draw moon and earth on paper
Tanvir and others	detect image	zooming on the image size
Xinguo and others	estimating the ball size depending on center circle or goalmouth	detect and track the ball in soccer game (online)
Our proposal	combination of the two previous methods 1) detect line or length in any image 2) estimating the ball size depending on radius of center circle or length of the penalty area or average players' length	determine the zooms in and out detect and track the ball in soccer game (online and offline)

7. CONCLUSION

In a variety of applications, a scale drawing is beneficial because a proportion between the dimensions of reality and of any image exists, where the dimensions indicate the natural truth on the image and the dimensions are less than the truth to make the image easier to read. In this paper, a new method was presented for computing the scale drawing via two methods, namely, line detector and length detector. First, in the images with a predefined scale drawing. Second, in the dataset of elite soccer player movements, where this work has successfully managed to reach the desired results.

In this paper, the ball size in soccer game was estimated based on identifying a set of salient objects in the court to their physical sizes such as the radius of the center circle or penalty area using a line detector, but if they do not appear in the frame, the ball size is estimated depending on the average player's height to their physical height using a length detector, but only for offline games. Therefore, for future work, another way must be investigated to estimate the ball size in the online game where salient objects in the court do not appear in the frame.

REFERENCES

- [1] J. Willis, S. Dogra. *AutoCAD 2019 for Architectural Design: A Power Guide for Beginners and Intermediate Users*. Independently published, 2018.
- [2] M. Irish, S. Ramanan. "A question of scale", *Elife*, vol. 8, no. September, 2019, doi: 10.7554/eLife.50890.
- [3] C. Fidler, S. Dotger. "Visualizing the Earth and Moon Relationship via Scaled Drawings.", *Sci. Scope*, vol. 33, no. 4, pp. 1419, 2009.
- [4] T. Prince, F. Traore. "Experiment of the Effect of Zooming on Image Sizes", no. January 2015, pp. 25, 2016, doi: 10.12691/ajna-3-2-1.
- [5] X. Yu, H.W. Leong, C. Xu, Q. Tian. Trajectory-based ball detection and tracking in broadcast soccer video. *IEEE Trans Multimed.* 2006;8(6):1164–1178.
- [6] Paperback. *Scale Drawings (Plans Handbook)*. 1986.
- [7] N. Meuser. *Construction and Design Manual: Architecture Drawings*. 2015.
- [8] K. Naglo, J. Mittag, D. Porter. Defining, Interpreting and Comparing Small Worlds of Football. An Introduction to the Aims and Objectives of this Special Issue. *Mov Soc.* 2019;61:5–11.
- [9] J. Christian, C. Jensen. Event detection in soccer using spatio-temporal data. *Comput Sci.* 2015.

- [10] T. Heath. *Mathematics in aristotle*. Routledge, 2015.
- [11] DLGSCI, *Sports Dimensions Guide For Playing Areas*, Sixth edit., no. June. 2016.
- [12] H.D. Najeeb, R.F. Ghani. A Survey on Object Detection and Tracking in Soccer Videos, no. 1, 2021, doi: 10.52113/2/.
- [13] S. Ågren. "Object tracking methods and their areas of application : A meta-analysis", *Master Thesis Comput. Sci.*, p. 45, 2017, [Online]. Available: <http://www8.cs.umu.se/education/examina/Rapporter/SannaAgrenFinal.pdf>.
- [14] R. Verma. A Review of Object Detection and Tracking Methods. *Int J Adv Eng Res Dev.* 2017;4(10):569–578.
- [15] M. Natasha. SketchUp Project - Scale Drawing. *Math J.* 2017.
- [16] M. Long. *Architectural acoustics*. Elsevier, 2014.
- [17] P.D.W.P. Pinelis. Model equations for the Eiffel Tower profile: historical perspective and new results. *Comptes Rendus Mec.* 2004;332(7):571–584.
- [18] M. Mata. Scale Drawing Project - 7th Grade Math, lecture, 2016, [Online]. Available: https://www.tes.com/lessons/CyKHFv_ddocfkg/scale-drawing-project-7th-grade-math.
- [19] S. A. Pettersen, *et al.* Soccer video and player position dataset. *Proc 5th ACM Multimed Syst Conf MMSys.* 2014;p. 18–23.