A.A. Petrov, E.M. Bozhko
Ural Federal University named after the first President of Russia B.N. Yeltsin
Yekaterinburg, Russia

WELDING SEAM TRACKING METHOD ANALYSIS

Abstract: analysis of welding seam tracking methods in automated robotic welding is presented in this paper. Analysis is performed to figure out current state of automated welding field. Robotic welding is being used in metalworking industry and allowing to increase welding precision and performance.

Key words: computer vision, robotics, welding.

Welding process has a few steps. First, a robotic manipulator is programmed with a trajectory. The trajectory describes a path of welding tool along the part that is being welded. The part is fixed on a special desk, and the welding procedure starts.

Obviously, the part can be fixed inaccurately, or the part may not completely conform to the programmed path.

Seam tracking systems are being used to avoid this problem. Its task is to ensure the welding accuracy using feedback loop during welding. In this way the robotic manipulator is allowed to correct the welding process in real time.

Seam tracking systems can be divided into few groups: laser sensor seam tracking, optical tracking and arc parameters tracking.

Laser sensor seam tracking

Laser sensor is a device, which allows to obtain a welding surface profile using laser triangulation: the surface is highlighted by a laser, then the camera takes a shot, and the obtained image is analyzed.

One of the solutions offers to search a seam on the image using a special mathematical operator, which describes pixel brightness. The resulting image is being processed with the Hough transformation. The result is being analyzed in order to get the seam coordinates [2].

Another solution offers to binarize the image first, and the seam coordinates are retrieved after. To stabilize the readings it is proposed to use a mean filter for finding the feature points [3].

One more solution offers to add spark and reflections filter to the mean filter. Afterwards curve reconstruction and feature point search are done [4].

Prasarn Kiddee offers to use cross-shaped highlight pattern, which implies a very simple way of finding its position on the image using a maximum sum of pixel brightness along both axes. A window is taken and analyzed with reference to this point. The analysis takes place in four steps: the areas are being refined to lines, then the equations of the lines are calculated, and then goes intersection solving and pattern matching [5].

Almost the same solution is offered by Fengshui Jing, with small difference. The cross-shaped highlight is not used here, but the fact is that the surface is turned in about the same direction as the x-axis. After the lines are found, feature points are calculated with the help of the distance between the line pixels and the image border [6].

Laser tracking is the most popular approach to seam tracking, but there are other solutions as well.

Optical tracking

Optical tracking differs from laser sensor tracking, because the welding surface is not highlighted with laser.

L. Zhou uses optical tracking for curved seam tracking. The trajectory is calculated from the image taken in front of the welding tool, thus allowing to calculate a tangential trajectory vector [7].

Huabin Chen proposes a combined system with a visual sensor and an arc detector, which allows taking shots between arc charges, yielding a clean image without any noise. The enhanced Canny algorithm is used for seam tracking [8].

Besides, it is offered to use a temperature gradient of the seam behind the welding tool to get seams coordinates [9].

Another kind of optical tracking is the analysis of welding spot. The analysis is supplied with area of fusion, wire feed [10] and canal highlight from the arc [11].

Arc parameters tracking

An alternative variant of getting feedback is arc parameters tracking. It is possible to make assumptions about the welding process while

measuring voltage, amperage and taking metal resistance into account [1], [12].

To sum up, we discussed welding seam tracking in an automated welding method. Methods are grouped in three categories: laser sensor tracking, optical tracking, and arc parameters tracking. Features of applied methods and algorithms have been described. Most methods rely on computer vision. Laser sensor tracking is the most popular method of seam tracking. Most technical papers describe joint gap welding presenting their methods. While it is the most common case, real world metalworking uses different joints. Improvement could be done to include more useful cases.

А.А. Петров, Е.М. Божко
Уральский федеральный университет имени первого Президента России Б. Н. Ельцина
Екатеринбург, Россия

АНАЛИЗ МЕТОДОВ СЛЕЖЕНИЯ ЗА СВАРНЫМ ШВОМ

Аннотация: в статье рассматриваются методы слежения за сварным швом при использовании роботизированной сварки. Анализ проводится для выяснения текущей ситуации в области автоматизированной сварки. Роботизированная сварка используется в металлообрабатывающей промышленности и позволяет увеличить точность сварки и производительность работы.

Ключевые слова: компьютерное зрение, робототехника, сварка.

СПИСОК ЛИТЕРАТУРЫ:

1. Леонидов П.В. Анализ различных методов поиска, слежения и измерения сварного шва // Мехатроника, автоматика и робототехника. – 2017. – № 1.

2. De Xu, Haiyong Chen, Zaojun Fang, Zhiguo Yan. Compact visual control system for aligning and tracking narrow butt seams with CO

2 gas-shielded arc welding // The International Journal of Advanced Manufacturing Technology. – 2012. – № 62.

3. Alberto Fernández Villán, Antonio Campos López, Daniel F. García, Eduardo Alvarez Alvarez, Jose Manuel García Sánchez, Rodrigo García Acevedo, Rubén Usamentiaga Fernández, Marco Jimenez Meana. Low-Cost System for weld Tracking Based on Artificial Vision // IEEE transactions on industry applications. – 2011. – № 3 (47).

4. W. P. Gu, W. Wan, Z. Y. Xiong. Autonomous seam acquisition and tracking system for multi-pass welding based on vision sensor // The International Journal of Advanced Manufacturing Technology. – 2013. – № 69.

5. Prasarn Kiddee, Min Tan, Zaojun Fang. An automated weld seam tracking system for thick plate using cross mark structured light // The International Journal of Advanced Manufacturing Technology. – 2016. – № 87.

6. Fengshui Jing, Junfeng Fan, Min Tan, Zaojun Fang. Automatic recognition system of welding seam type based on SVM method // The International Journal of Advanced Manufacturing Technology. – № 92.

7. L. Zhou, T. Lin, S. B. Chen. Autonomous Acquisition of Seam Coordinates for Arc Welding Robot Based on Visual Servoing // Journal of Intelligent and Robotic Systems. – 2006. – № 47.

8. Huabin Chen, Jiyong Zhong, Na Lv, Shanben Chen, Yanling Xu. Research on the Real-time Tracking Information of Three-dimension Welding Seam in Robotic GTAW Process Based on Composite Sensor Technology // Journal of Intelligent and Robotic Systems. – 2012. – № 67.

9. Hua Zhang, Shaobin Peng. The seam recognition with computer vision and its application // Processing of SPIE 4925, Electronic Imaging and Multimedia Technology III. – 2002. – № 4925.

10. K. C Ahn, K. Y. Bae, T. H. Lee. An optical sensing system for seam tracking and weld pool control in gas metal arc welding on steel pipe // Journal of Materials Processing Technology. – 2002. – № 120.

11. Gu Fang, Ju Jia Zou, Na Lv, Shanben Chen, Yanling Xu. Computer vision technology for seam tracking in robotic GTAW and GMAW // Robotics and Computer-Integrated Manufacturing. – 2015. – № 32.

12. Donghun Le, Jongwon Kim, Ju-hwan Cha, Kyu-Yeul Lee, Namkug Ku, Sol Ha, Tae-wan Kim. Development of a mobile welding

robot for double-hull structures in shipbuilding // Journal of Marine Science and Technology. – 2010. – № 15.