

Painting watercolor artworks with Busker Robot

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Abstract—Busker Robot is a robotic installation capable of reproducing watercolor artworks, starting from a digital image, which is processed through the application of algorithms for artistic rendering. The system is composed of a 6-DOF robotic arm equipped for brush painting purposes. The random effects given by the rendering techniques, the properties of watercolor painting and the interaction between the artist and the robot produce interesting and original results.

I. INTRODUCTION

Robotic systems are becoming an important technology used by artists to discover and develop novel forms of expression and contemporary art. In the last years, several examples of robotic painting systems have been proposed and shown to the public as artistic installations. Examples can be found in the works of Aguilar and Lipson [1], Tresset and Leymarie, [2], and Lindemeier *et al.* [3]. Other recent examples are the collaborative robot drawing graffiti strokes presented in [4], the robotic airbrush system shown in [5], and the painting robot developed by Karimov *et al.* [6].

Busker Robot is a robotic system capable of realizing watercolor artworks, starting from a digital image, which is processed through the application of algorithms for artistic rendering. The system has been firstly presented in [7] and [8], whereas its latest developments have been shown in [9].

The system leverages on *non-photorealistic rendering techniques*, that allow to extract the contours and the backgrounds of an image to be reproduced in an artistic manner. The hardware is composed of a 6-DOF collaborative robot, equipped with a changeable brush for watercolor painting. With respect to a system composed of a conventional printer, during the painting task, the artist controls both the software and the hardware variables, influencing not only the output of the algorithms but also the color and the brush parameters.

Moreover, robot *expressive motions* are extremely important and the gesture activity during the painting is one of the targets of our artistic expression, since action priming, when congruent with the artist's painting style, better contributes to the appreciation of the artworks [10].

Possible industrial applications of the robotic system could be the artistic painting of ceramics, inlaid wood, furniture and design objects.

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Fig. 1: Busker Robot.

Busker Robot has been exposed at several fairs and international exhibitions, and took part of the 2018 RobotArt Competition, where he won an Honorable Mention.

II. THE PAINTING MACHINE

The robotic system is a 6-DOF collaborative robot, by Universal Robots, shown in Fig. 1. The robot, usually employed in industry for pick-and-place, gluing or packaging tasks, has been equipped for brush painting purposes, using an aluminum flange connected to the end-effector and 3D printed brush supports. The position of the target surface, paint cups, and brush tool repository is provided to the system before starting every artwork with a proper calibration procedure. For the painting task, we adopted watercolor brushes and rough high-density paper.

In order to obtain an experimental estimation of the brush-stroke parameters, the stroke width and the color intensity along the stroke, the brushing mechanism has been analysed. The brushstroke characterization is, indeed, an important and essential procedure, if a prediction of the paint deposition along the strokes is needed, as done in [6], [11].

III. ALGORITHMS FOR ARTISTIC RENDERING

The artistic rendering algorithms, that have been developed for the processing of the input images, aim at extracting and elaborating both the contours and the backgrounds. For the details and contours we have implemented classical algorithms, such as Canny Edge Detector, Hough Transform and Difference of Gaussians. For the large areas and backgrounds, we developed and implemented algorithms, capable of introducing a random effect in the way an area is filled. Examples are the Random Strokes [7], in which an area is filled by lines starting from random points, and Random

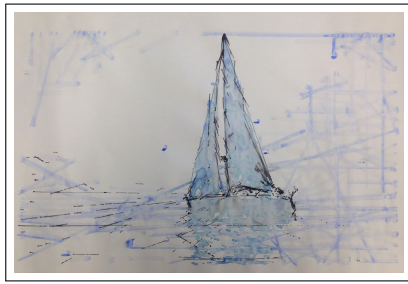


Fig. 2: Sailboat.



Fig. 3: Amanda.



Fig. 4: Trieste Seafront.



Fig. 5: Sailboat, original.

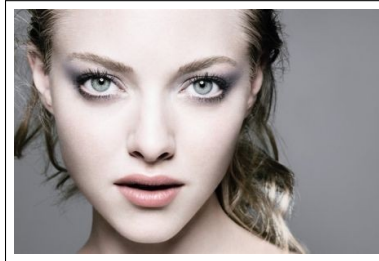


Fig. 6: Amanda, original.



Fig. 7: Trieste Seafront, original.

Hatching [8], a variant of the hatching technique with random perturbations of starting and ending points. The algorithms are applied to layers of the image, obtained with a threshold procedure, in a way similar to [12].

The output of the algorithms is the sequence of points that constitutes the paths, that the robot has to follow to complete the artwork. A *trajectory planning* is applied to these paths, in order to set the motion law that the robot end-effector has to follow, as well as the motions needed for the color refill and the brush cleaning, akin to those of a human artist.

IV. EXPERIMENTAL RESULTS

Figures 2, 3 and 4 report three examples of experimental watercolor artworks realized by Busker Robot, starting from the images reported in Figs 5, 6 and 7, respectively. In the artworks, the random effects introduced in the algorithms, as well as the effects of the watercolor technique, such as transparency, granulation, edge-darkening and paper ripples (which cannot be easily reproduced on paper by a conventional printer), can be appreciated. Even if a quantitative analysis of the results is not possible, since the appreciation of an artwork is subjective and personal, the artworks produced by Busker Robot are original in their artistic style, and cherished by the visitors of the fairs to which Busker took part.

V. CONCLUSIONS

Busker Robot is a system capable of performing watercolor painting, by means of a 6-DOF robotic arm. It is based on the processing of a digital image with several non-photorealistic rendering techniques, that extract and process the backgrounds and the contours. The random effects given by the rendering techniques, the properties of watercolor painting and the artist-robot interaction generate interesting and original results. Robotic painting is still a challenging

and complex task. In the future, we plan to further investigate the brushing mechanisms, to improve the paint deposition and develop novel artistic rendering algorithms for watercolor automatic painting.

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