942. Analysis of planned motion trajectories for scalable micro-robots

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Abstract. Prototypes of micro-robots and geometric path planning algorithms are presented in this paper. Geometric motion trajectories are generated by switching contacts, control points and tangents methods. Analysis of high-speed formation of trajectories using switching contacts method revealed that the geometric path depends on orientation angle of a micro-robot. Investigation of formation of high-precision trajectories demonstrated that there is minimal deviation from the given motion trajectory at which micro-robot stops. This paper presents methodologies for evaluation of optimal orientation angle of a micro-robot and minimum deflection from the given trajectory. The methodologies are verified by experiments.

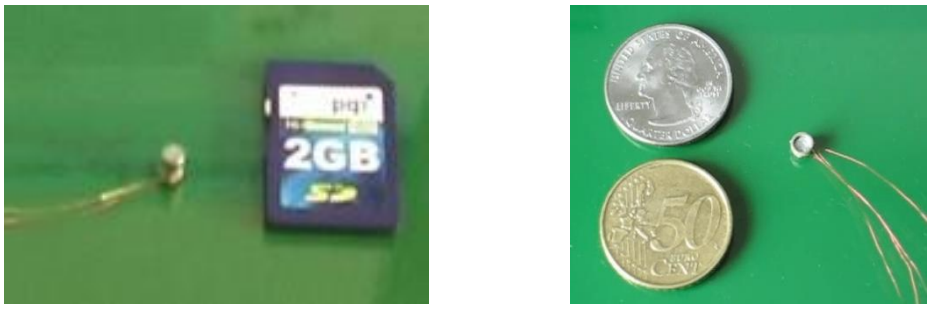
Keywords: micro-robot, path-planning algorithms, optimal orientation angle, minimum deflection.

1. Introduction

Most of the high-precision positioning devices that have been developed so far are driven by piezoelectric actuators [1-6], which possess high resolution, high stiffness and quick response. However, the strokes of piezoceramic transducers are extremely small.

R. Bansevičius and K. Ragulskis were the first who in 1989 presented 6-DOF and 9-DOF micro-robots that consisted of two kinematic pears: piezoelectric cylinder – passive sphere, piezoelectric disc – passive plane [7]. 3-DOF piezoelectric motor for motion or rotation by passive plane was proposed. It was piezoceramics mounted on metal plate and electrodes divided to equal 120° sectors [8]. Rotation is accomplished by means of travelling wave. During research work of positioning objects, piezoelectric ring-shaped, cylinder-shaped and hemisphere-shaped micro-robots were developed.

The potential application of these micro-robots is mini/micro lasers, in particular for industrial processes. As shown by experimental studies, the minimum dimensions of the micro robot can be reduced to a few millimeters (Fig. 1).



a) b)

Fig. 1. 3-DOF piezoelectric cylindrical actuators: a) 4 × 3 × 4 mm; b) 8 × 6 × 8 mm ($D \times d \times h$)

Piezoelectric ring-shaped micro-robotic schemes feature – ability to realize larger masses positioning systems (Fig. 2). In control of motion direction (without return communication