

Fig. 1 Two animals with rolling capability (a) Web toed salamander [3] (b) Namib Golden Wheel spider [4].

Fig. 2 Proposed robots with four distinct moving modes.

Fig. 3 Two proposed robots, CQR and SQR in left and right respectively.

Fig. 4. (a) The first prototype of the SQR. (b) Equipment of prototype, (1) motor1, (2) pendulum, (3) Joint between two hemispheres with its servo (4) wireless and main board and other equipment.

Fig. 5 CQR in rolling mode.

Fig. 6 SQR in rolling mode.

Fig. 7 CQR in rolling mode in three views

Fig. 8 Equivalent model of the SQR.

Fig. 9 (a) Schematic model of SQR in the side view (b) in the top view.

Fig. 10 SQR in uphill rolling.

Fig. 11 Comparison between the robots proposed in this paper and ordinary spherical robot in the (a) planar motion (b) uphill motion.

Fig.12 The change in the robot situations from open to close mode.

Fig. 13 The torque of motor 1 in constant low, medium, high rotational speed of the motors, (green lines (—) for simulation and blue lines (--) for analytic relations.

Fig. 14 (a) first (green) and second (blue) terms of (36) for different acceleration.

Fig.15 Circular trajectories for (a) $\lambda = 15.3^\circ$, (b) $\lambda = 12.1^\circ$, (c) $\lambda = 8.3^\circ$, (d) $\lambda = 5.7^\circ$, (red lines (--) for simulation and the blue line (—) for analytic relations), experimental path of the robot (O). (b) Square path trajectory of the prototype (c) Experimental results of the robot in a square trajectory.

Table. 1 The information of the electrical components of the prototype.

Table. 2 The structural information of the design.