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Optimal Design for Permanent Magnet Distribution of the Tip of Flexible Endoscope Driven by Magnetic Navigation

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The traditional endoscope mainly relies on the operation of the operator. The intestinal wall is often deformed and bent when pushed the operator pushed endoscope in, which increases the probability of damage to the intestinal tissue. Here, a flexible endoscope (FE) is developed that overcomes the shortcomings of traditional endoscopes. In order to improve maneuverability, a permanent magnet ring is placed on the tip of the FE, and an external magnetic field generated by a magnetic navigation system composed of eight electromagnetic coils is used to guide it. The FE is made by transforming the traditional endoscope, and the number, position, and size of the permanent magnet ring at its tip are optimized through the finite element model(FEM). Since the endoscope is made of deformable material, it can be guided to the small intestine farther away using an external magnetic field. Experiments are conducted on various angles of the FE in the deformation angle range of 0 to 180° under various magnetic fields and found that these angles can be accurately estimated by the FEM. To verify the feasibility of magnetic navigation driving the FE for intestinal inspection further, the experiments are conducted in the intestinal model and the isolated intestine respectively use the magnetic navigation equipment to control the FE, and the performance of the optimized FE was evaluated by the X-ray machine imaging system.

Index Terms—Magnetic navigation, Flexible endoscope, Permanent magnets

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