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Design of a Customized Waterproof Magnetic Connector (WaMaCo) for Semi-disposable Endoluminal Instruments

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***Abstract*— Endoscopes are essential equipment for the screening of gastrointestinal tract. Due to their lower cost and complexity, single-use endoscopes are recently more and more adopted in the clinical practice. However, the use of disposable endoscopes arises environmental impact and a few components, e.g. camera and optics, could be reused also due to their cost if of high quality. To mitigate this issue, we developed a customized waterproof magnetic connector (WaMaCo), acting as possible element to be utilized in between a disposable and a reusable portion of new generation endoscope.**

***Clinical Relevance*— WaMaCo has the potential to reduce the impact of disposable endoscopes by recycling components and enabling green high-performance approach.**

I. INTRODUCTION

Cancers of the gastrointestinal tract are among the five most frequent and mortal cancers. Nonetheless the survival rate to these tumors can be dramatically increased by early diagnosis, so periodic screening is needed [1].

In the recent years, the demand for single-use endoscopes has increased significantly [2]. However, the use of disposable devices leads to an increase in waste production, which cannot be gladly accepted in the new green era [3]. A possible and easy way to contribute to the reduction of the impact on the healthcare system and environment may be to integrate smart connectors between a disposable portion (tail) and a reusable element with electronics (head) of the endoscope, leading so to a new semi-disposable low-cost approach with high performances.

II. METHODS & RESULTS

WaMaCo consists of a male and female element exploiting attraction forces between small NdFeB magnets to guarantee electrical continuity. Magnets are commonly used in medical devices for tracking and locomotion but not as circuitry elements due to possible magnetic losses for the Joule heating effect [4]. However, the use of magnets to close a circuit may be very advantageous allowing to set less strict requirements on design and manufacturing of electrical pins and embedding, at the same time, possible additional degrees of freedom or constraints into the system. Considering cylindrical magnets (radius and height: 1 mm), a standard gastroscopy procedural time of 15 min and a flowing current of 200 mA (e.g., max. current for our CMOS camera) the temperature increase estimated by Joule heating law is lower than 2°C. So, even considering body temperature as the initial one this increment will neither lead to patient harm nor to magnetic losses.

WaMaCo embeds six electrical lines and an O-ring to guarantee waterproofness, which is fundamental for the target application. Both diameter and height are lower than 30 mm and system dimensions can be further reduced by using smaller magnets. Components were designed with ANSYS Workbench 2020 and 3D-printed with VisiJet M3 Crystal (3D Systems, Inc., USA) (see Figure 1). To realize magnet-wire connections mechanical means have been exploited, locking magnets inside their seats on top of spiraling bended wires.

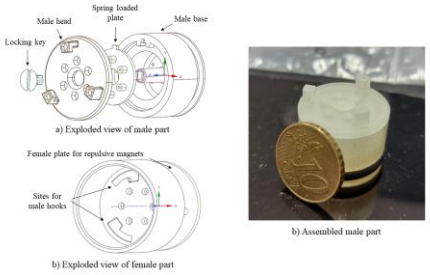

Figure 1. Overview on WaMaCo design.

Preliminary electrical tests have been performed with an oscilloscope to confirm electrical signal quality. Experimental results showed that there is neither signal loss nor instability. Moreover, we qualitatively demonstrated the function of the connector with LEDs and a CMOS camera (resolution: 320x240) also under a sever wet condition.

III. DISCUSSION & CONCLUSION

This proof-of-concept demonstrated the feasibility of using magnets to close electrical circuits. In addition, our novel magneto-mechanical design resulted mechanically stable and waterproof to set the stage for a new generation of more advanced, cheaper, and eco-friendly disposable endoscopes.

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