Dear Dr. Liesbeth Venema, Editor-in-Chief of the Nature Machine Intelligence Journal,

We wish to submit a manuscript entitled “**Learning-based Damage Recovery for Healable Soft Electronic Skins”** for consideration for publication in Nature Machine Intelligence. We confirm that this work is original.

**Our work combines for the first time three fast-growing fields “Machine Intelligence”, "Flexible Electronics" and "Self-Healing Materials".** **The authors believe that the combination of machine learning and self-healing can provide robust and long-lived soft sensorized systems able to cope with multiple types of damage via healing on the material level and adaptation on the software level.** Extending the lifetime of complex systems is both economical, as maintenance and offline times are reduced, as well as ecological, being in line with the sustainable global goals. Being multidisciplinary, we believe this research paper will receive a high amount of citations from these fields and many more, including (soft) robotics. To spur this new multidisciplinary research, we would like to disseminate this research paper in Nature Machine Intelligence.

The research is performed in a close collaboration between the University of Cambridge and the Vrije Universiteit Brussel in the framework of an EU-project, the  FET Open project SHeRo on self-healing soft robots (<http://www.sherofet.eu/>). In this project, we are using self-healing polymers to construct soft robots, with an incorporated healing capacity. It is clear that soft sensors play an important role in soft robotics, but also in smart wearables, human-robot interfaces, etc. These flexible sensors are susceptible to damage, like the flexible devices in which they are embedded. **Although many studies have proven the potential of healable soft sensors, all these works are limited to the recovery of electrical properties after damage and have not investigated the functional integrity of the sensors after a damage-heal cycle.** This is mainly because of the challenges involved in modelling these highly non-linear and time-variant polymer sensors.

As illustrated by the highly cited review paper “Electronic skins and machine learning for intelligent soft robots” published by the authors in Science Robotics (IF 23.75, cited by 114 in less then 2 years), machine learning can provide an alternative for modulization of electronic skins. **These techniques have never been applied to healable soft sensors, which are in general highly non-linear and time-variant. In this paper we present for the very first time a learning-based framework for the characterisation of a healable electronic skin.** We showed that the use of deep neural network with sensor history resulted in a high-resolution electronic skin able to localize touch with a high resolution of 2 mm and a correct depth estimation of nearly 100%, even with highly non-linear healable sensor fibres.

In order to truly enhance longevity of healable sensors and the systems in which they are embedded, healing of damage should involve minimal sensitivity deterioration. Although full restoration of the sensor response after healing is possible upon excellent recontact, its recovery will always be highly influenced by the slightest misalignment or insufficient contact. **In future applications that demand autonomous healing and multiple damage-healing cycles, non-optimal healing will be unavoidable.** Consequently, the sensitivity decreases and sensors become unreliable. In these cases, recalibration is inevitable to preserve sensor sensitivity. **In this paper, it is shown that full resampling and retraining of the network on the healed electronic skin regains original performances, and even improves it in some cases.** In addition, the proposed approach also allows us to exploit redundancies, which provides an additional temporary robustness to damages. Although, training from scratch is reliable, it limits future applications as it will be time-consuming and costly. This problem is tackled by t**he introduced transfer learning approach that presents a fast alternative for model adaptation with reduced data points.**

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Thank you for your consideration of this manuscript.

Sincerely,

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