

Purpose: To demonstrate real-time automatic patient head motion correction during radiation therapy with non-magnetic and non-radiation attenuating robots. Contrary to current methods, this would (i) remove the need for frames or thermoplastic masks; (ii) negate the deleterious effects of interfractional setup variation; (iii) correct the complex intrafraction geometric uncertainties; (iii) and be applicable for use in combined MRI-LINAC systems.

Methods: A soft robot mechanism was designed to move the patient's head into desired trajectory regimes. The soft robot consists of non-attenuating and non-magnetic soft actuators, whose respective deformations are controlled by the compressed air volume within their internal chambers. Inspired from the behavior of the papillae skin of certain cephalopods, we fabricate dome-like soft actuators, planar in their reference configuration, but which transform into full 3D textures in their current configuration. We carry out simulations to verify their fast and precise prehensile manipulation of a patient's head.

Results: Our results show the displacement of the head from a rest position of 0mm to a target position of 10mm above the table based on the Circumferentially COncentric And Radially Symmetric Elastomeric (CCOARSE) deformation property baked into the actuators' design. The head reaches the desired target in world coordinates within a rise time of <20%.

Conclusions: This work shows the potential of real-time head motion correction with non-magnetic and a radiation-transparent soft robot adaptable for standalone radiation therapy. The proposed technology can be used in emerging hybrid MRI-linear accelerators; and can spur the emergence of a better brain and head and neck (H&N) cancer management technology that can be adapted to confined spaces under MRI coils. Their continuum nature assures minimal invasiveness and patient comfort. Their actuation medium (air) eliminates the risk of electronic/metallic parts that are unsuitable for the MRI's magnetic fields and makes it safe for human-robot interaction.