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Computational Modeling of an MRI Guided Drug Delivery System Based on Magnetic Nanoparticle Aggregations for the Navigation of Paramagnetic Nanocapsules in the Cardiovascular System

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Magnetic targeting aims at using magnetic particles as carriers of drug against tumors and cancer cells. The navigation of nanoparticles is implemented by making use of clinical Magnetic Resonance Imaging (MRI) producing a three-dimensional guiding magnetic forces. The key intention of the method is increasing the drug dosage in the targeted region and lowering it in the healthy tissues. Conventionally, external magnets are used to attract magnetic particles in a selected region.

A computational platform using OpenFOAM program for magnetically guided drug delivery is presented. Simulation and analysis of the aggregation process of magnetic particles within a fluid environment exhibiting laminar flow is also described.

To develop the propulsion simulation module, 5 forces are considered.
i) *Magnetic forces* from MRI's Main Magnet static field as well as the Magnetic field gradient force from the special Propulsion Gradient Coils. The static field caters for the aggregation of nanoparticles while the magnetic gradient for the navigation of the agglomerations.
ii) *Contact forces* among the aggregated nanonparticles.
iii) *Hydrodynamic force* on each particle are based on the Stokes drag force for a sphere.
iv) *Gravitational forces* due to gravity and the force due to buoyancy.
v) *Van der Waals forces* act among the particles when they are not in contact.

The present work can simulate the motion of the aggregations when these are driven by MRI magnetic gradients. The optimum drug delivery is investigating through the implementation of several magnetic gradients and aggregation patterns of nanoparticles.

The simulations are validated by comparing with experimental results provided by [2] where a very good conformity with the experiment can be identified.

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