Development of a Real Time Image-Based Guidance System of Magnetic Nanoparticles for Targeted Drug Delivery

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Magnetic nanoparticles (MNPs) possess the ability to function at the cellular and molecular level of biological interactions, making them an attractive platform as contrast agents for Magnetic Particle Imaging (MPI) and as carriers for targeted drug delivery (TDD) . TDD by using MNPs is an efficient technique to deliver drug molecules towards specific tissues in a human body.

The MNPs' guidance system is a combined electromagnetic actuation (EMA) and monitoring system, which can provide an accurate control scheme with MNP's localization for more precise targeting of the drug delivery. The localization of the MNPs is done on the basis of MPI with low amplitude excitation field. In this paper, we have developed a novel guidance system for MNPs position control, by alternately supply of different currents to coils set in time sequence, the coil set alternates functions between MPI and EMA simultaneously. Motion of MNPs is controlled by a gradient of magnetic field in EMA period, the distribution of MNPs is detected in MPI period and provides feedback to the EMA. The guidance system will provide simultaneous navigation and tracking for targeted drug delivery of MNPs in compact and efficient ways.

The experimental setup is shown in Figure (a). We apply a.c. current with d.c. offset in each differential current coils (DCCs) to achieve field free point (FFP) and scanning MNPs' distribution in workspace. The size of workspace is 3.5cm. The tube filled with MNP suspension was placed in workspace. MNPs aggregated into a cluster, which was moved by gradient field generated by DCCs during EMA periods. The distribution of MNPs was reconstructed as MPI image (Figure (b)). The core sizes of MNP used for guidance system are 60nm (Magqu, 2.67Fe-mg/ml) and 5mn (Resovit, 2.83 Fe-mg/ml). The 1D MNPs guidance system has 0.3s MPI time and 0.2s EMA time, allowing a position control of MNPs. The movement of MNPs cluster could be observed from both camera and MPI image. The gradient field is 3T/m for MPI. The experimental results show that the real time MPI-based guidance system could achieve MNPs position control with 2Hz MPI image update frequency, namely hybrid system frequency.

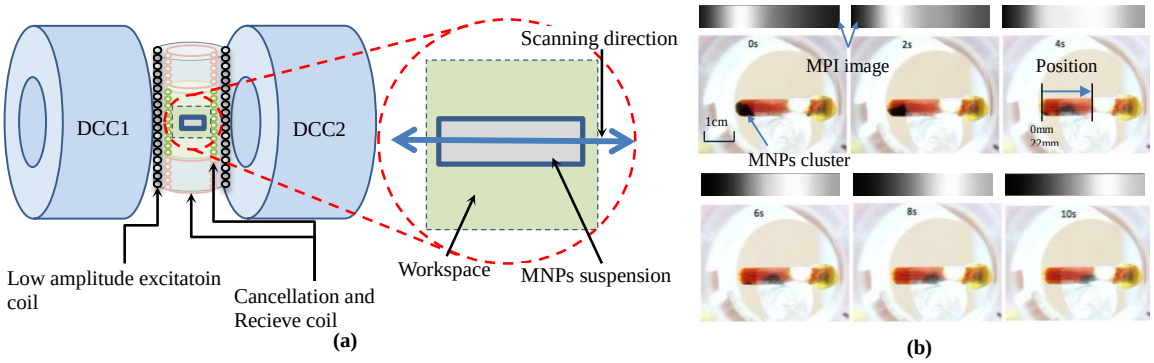

Figure. **(a)** 1-D Guidance system with 1 set of DCC1 and DCC2 and an excitation coil combined with a receive coil. The DCCs are used as actuation coils during EMA period and generated selection field during MPI period, and combination of excitation and receive coil is used to generate excitation field and collect MNPs signal. the MNPs suspension sample is filled in a glass tube, and placed in workspace along the scanning direction. **(b)** MNPs are manipulated by guidance system. Magnetic force was to the right side, and during steering the particle cluster, MPI shown the position of cluster (90nm). The high concentration of MNPs is show in white and low in black.