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Patients' Lung Debris Cleaning Nanorobot: Optimize Electromagnetic Field and Its Excitation Mechanism to Precisely Control Nanorobot in Real-time

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Abstract: The patients suffer from acute respiratory distress syndrome (ARDS) because the debris of damaged lungs occupies the alveolus. In order to remove the debris, the medical nanorobots can be employed to clean the blocked respiratory path. Currently, medical nanorobots are investigated to fight diseases by assuming to work inside human bodies. They can be in various forms (plate, particles, tubes, wires) and powered by acid, liquid, magnetic field, or ultrasound wave. Although Nature's nanorobots have appeared in some publications, there is still a long way from being able to mimic nature's innovations. Therefore, the nanorobots motorized by various powers are good candidates in the near future. In addition, the complexity inside the human body suggests that the power sources involving the human-body itself (acid or liquid) are not so reliable. So, the external power source should be a reasonable solution to improve the robustness of the nanorobots. Currently, the common external power sources include magnetic and ultrasound, and after comparing their other applications, the magnetic power is better for fighting disease. Hence, the magnetic is selected to power nanorobot here. Unfortunately, the available prototypes or researches only have limited capabilities to navigate and control the path of the nanorobot due to the difficulties with respect to the real-time analysis of the magnetic field and the optimization of the excitation mechanism. Therefore, the proposed project will focus on the optimization of the excitation mechanism, and real-time analysis and control of the electromagnetic field in order to find an efficient way to remove the debris in the patients' lungs.

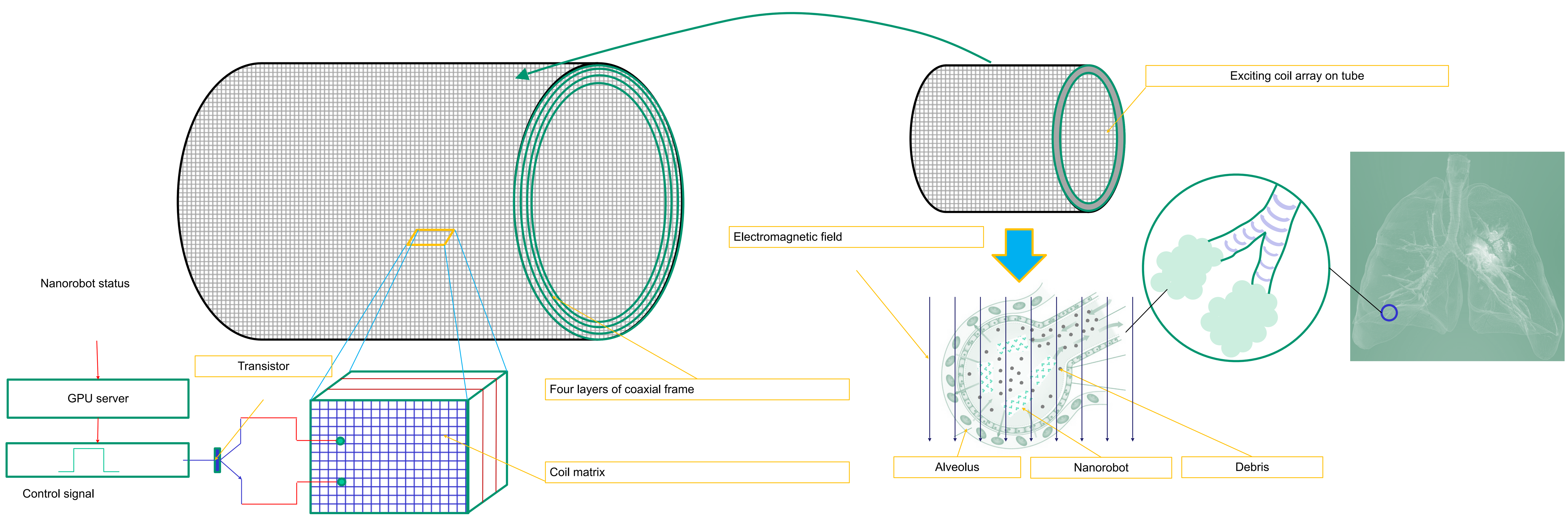

Figure 1: Principle of electromagnetic nanorobot

Nanorobot is employed to remove the debris accumulated in the alveolus as shown in Figure 1. The nanorobot itself is fabricated to collect debris and keep running to deliver the debris outside of the body (the pattern on nanorobot represents the collected debris). This nanorobot is motorized by the electromagnetic force which is excited and controlled by a coil array on a tube (refer to Figure 1). The elements of coil array are logically controlled through transistors based on the requirement of navigation and control. So, the patterns of the transistors' operation will change the distribution of the magnetic field, magnetic force, and decide the behavior of the nanorobot.

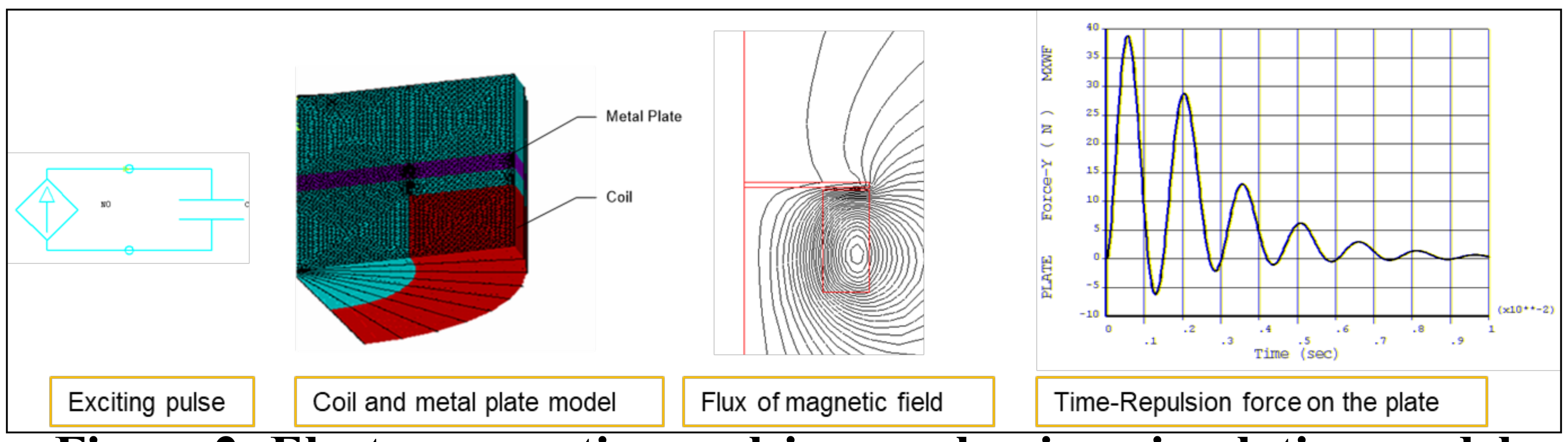

Figure 2: Electromagnetic repulsion mechanism simulation model

Using CUDA-based parallel computing to calculate the electromagnetic force. The basic theories to do the electromagnetic field analysis is Maxwell's equations. The nanorobot is driven by repulsive force resulting from an eddy current. The model used to simulate such kind of mechanism can be found in Figure 2 . This model includes one coil and one metal plate. The eddy current is generated in the plate when a pulse is exciting an electromagnetic field around the coil. The eddy current will generate one electromagnetic field which is a reversal to the coils. The flux of the magnetic field and the force on the plate can be found in Figure 2.

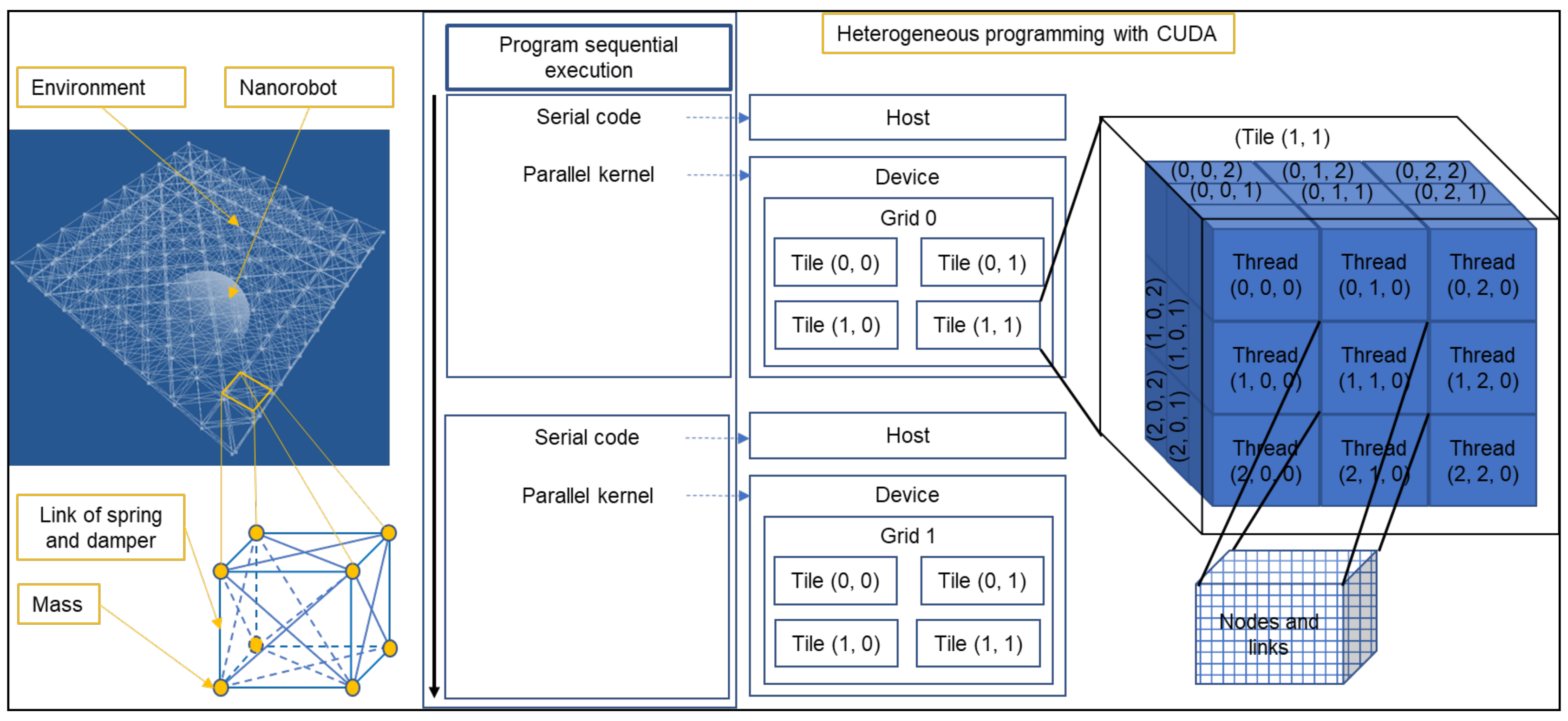

Figure 3: Demonstration of a procedure-oriented immersive assembly platform

Optimization of the topological problem to handle nanorobot movement involves stochastic dynamics. CUDA-based parallel computing and Verlet integration Scheme with error $O(\Delta t4)$ are used to simulate the dynamic behavior of the nanorobot and its environment (refer to Figure 3).