Position estimation with algorithm considering the angle character for the capsule endoscope in high-definition numerical human body model

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Currently, wireless power transmission technology is being developed for the capsule endoscope. By removing the battery, it is expected that the capsule endoscope will be downsized, the danger of damage in the body will be avoided, and the number of images taken will increase. Furthermore, by estimating the position of the capsule endoscope, improvement in diagnostic accuracy can be expected. In this study, we proposed the algorithm for the position estimation and evaluated the performance of it in a high-definition numerical human body model developed by NICT japan.

We used the trilateration method proposed in previous study [1]. In the method, there may be no intersection of spherical surfaces. Therefore, the magnitude pattern of the measured Received Signal Strength (RSS) was normalized and added to the original RSS to correct the method. In addition, the angle character of the receiving antenna has been investigated in previous study as a factor that affects the estimation accuracy [1]. Therefore, in this study as well, the final estimation result was obtained by adding a correction that takes it into consideration.
We used helical antenna as transmitting antenna for capsule endoscope and two wire spiral antenna as receiving antenna [2]. Each antenna is designed to operate at 433.92 MHz. Figure 1 shows the simulation model. Similar to the previous study [3], only the abdomen was taken out from the high-definition numerical human body model, and a capsule endoscope was implanted inside the small intestine of that model. Position estimation was performed at 78 points in the small intestine. Finite Integration Method (FIM) was used to simulate the RSS.

Figure 2 shows the result of position estimation. We achieved an estimation error within 40 mm or less at 72 points, which is 92% of all points. Estimated accuracy improved by about 12% compared to the estimation results in previous study [3]. Position number 59, 63, 69, and 76 in Figure 2 are positions where the capsule endoscope is away from the receiving antenna. In addition, these locations are adjacent to tissues such as the large intestine and stomach. From this, it is considered that the electromagnetic wave is reflected at the boundary surface, and the error of the distance between the antennas calculated from the distance characteristics [1] is large because the receiving antenna receives RSS from multiple paths.

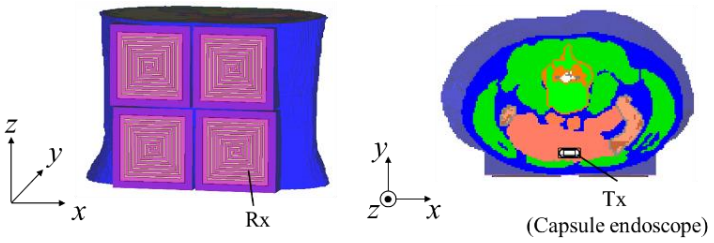

Figure 1. Simulation mode and the capsule in small intestine

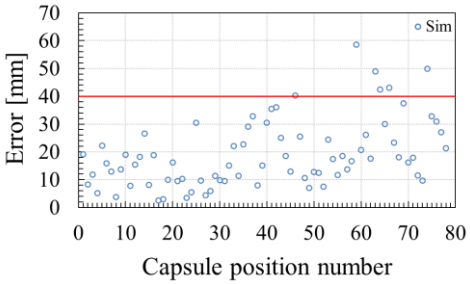

Figure 2. Result of position estimation

References

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