# A parallel computing approach for optimization of a single-element transducer position in transcranial focused ultrasound application

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## Purpose

Transcranial focused ultrasound (tFUS) neuromodulation is one of the most promising techniques that can noninvasively stimulate the specific region of the brain. Due to the presence of the skull, the in-situ acoustic focus can be displaced. The previous study suggested that the placement of a single-element tFUS transducer with the lowest average reflection coefficient (ARC) would provide the optimal position [1]. In this study, we present an image-guided navigation system with accelerated ARC calculation by parallel computing approach.

## Methods

NVIDIA OptiX Ray Tracing Engine is a framework for achieving accelerated ray tracing on the Graphic Processing Unit (GPU). Ray tracing is an image rendering technique to track the path of ray and to simulate the interaction with ray and virtual objects. We applied this technique to get the reflection coefficient at each straight lines (rays) heading the brain target. Additionally, Visualization toolkit (VTK) was used to generate 3D mesh models including a transducer and skull object. By utilizing this framework, our system could perform a large number of ray tracing tasks in parallel. This system was developed on a desktop PC with 2.21GHZ CPU(i7-8750H) and NVIDIA GeForce GTX 1070 GPU.

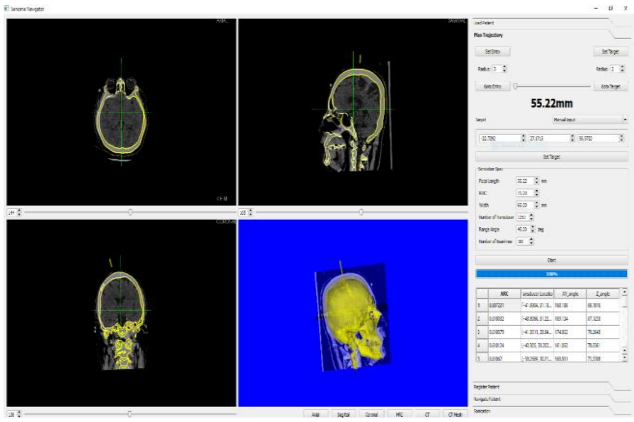
## Results

The proposed system is able to find the optimal position in about 4s considering 1250 possible positions for four different cortical brain areas (SMA, DLPFC, S1, and M1). It took about 2.4% of the previous ARC method implemented in Python using VTK. Compare to the acoustic simulation, the computation time only took about 0.002% of it.

## Conclusion

The proposed image-guided navigation system showed high computational efficiency to find the optimal position of a single-element tFUS transducer, which can be used for real-time guidance of optimal sonication path for a specific brain target.

| Target | *ARC* calculation | | Acoustic simulation |
|---|---|---|---|
| | C++/OptiX | Python/VTK | |
| SMA | 5 s | 166 s | 224,820 s |
| DLPFC | 4 s | 187 s | 225,000 s |
| S1 | 4 s | 180 s | 216,180 s |
| M1 | 4 s | 181 s | 225,000 s |
| avr | 4.25 s | 178.5 s | 222,750 s |




## References

**[1]** T. Park, K.J. Pahk and H. Kim. **Method to optimize the placement of a single-element transducer for transcranial focused ultrasound** Comput. Methods Programs Biomed., 179 (2019), 10.1016/j.cmpb.2019.104982