UNIVERSITY OF COPENHAGEN

Saving the Human Race

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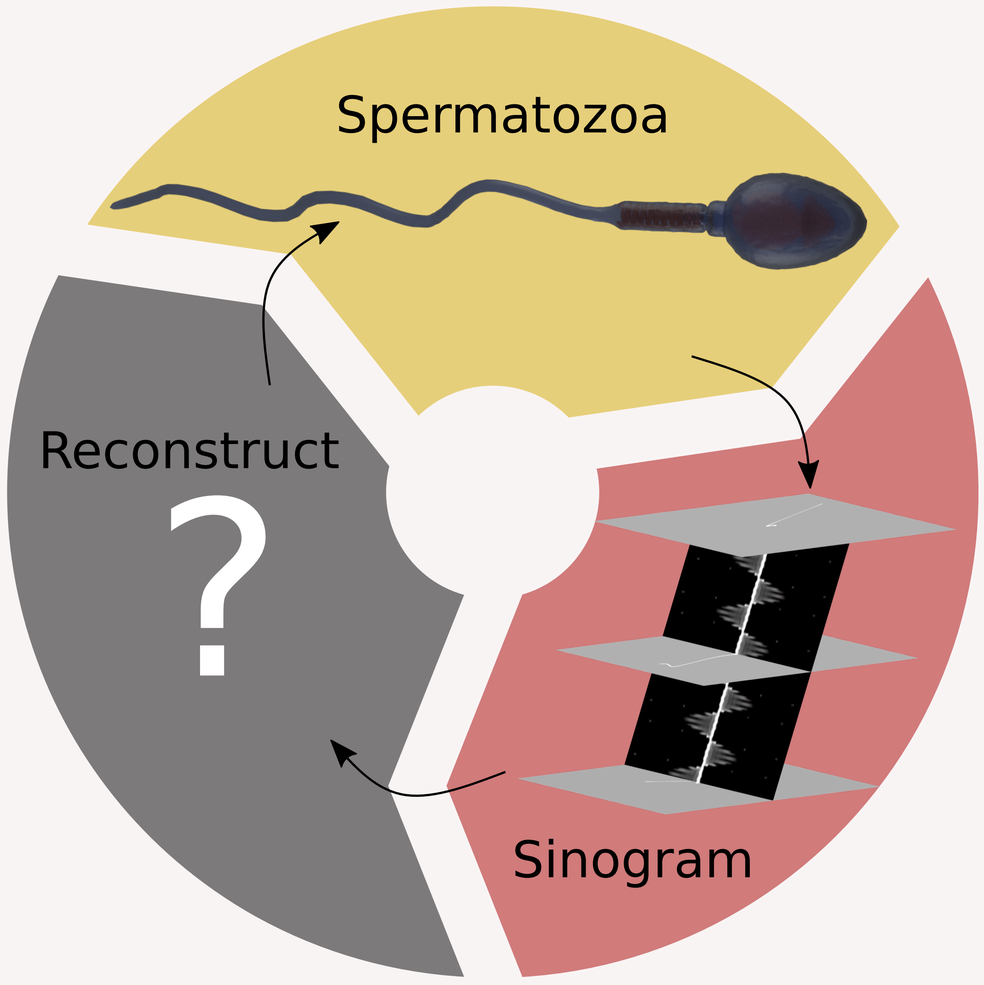
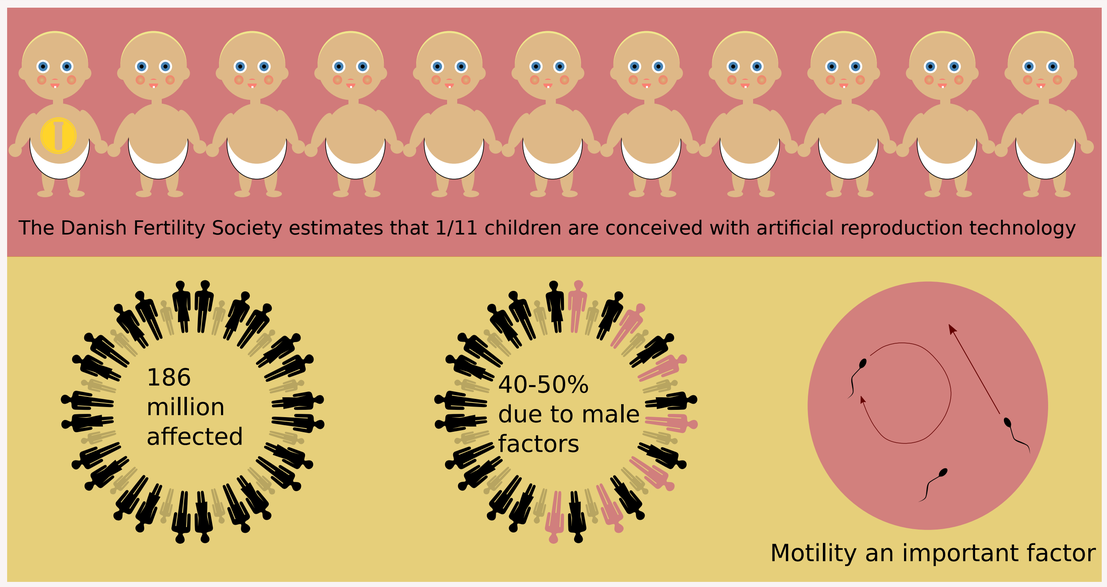
First 4D reconstruction of a spermatozoa



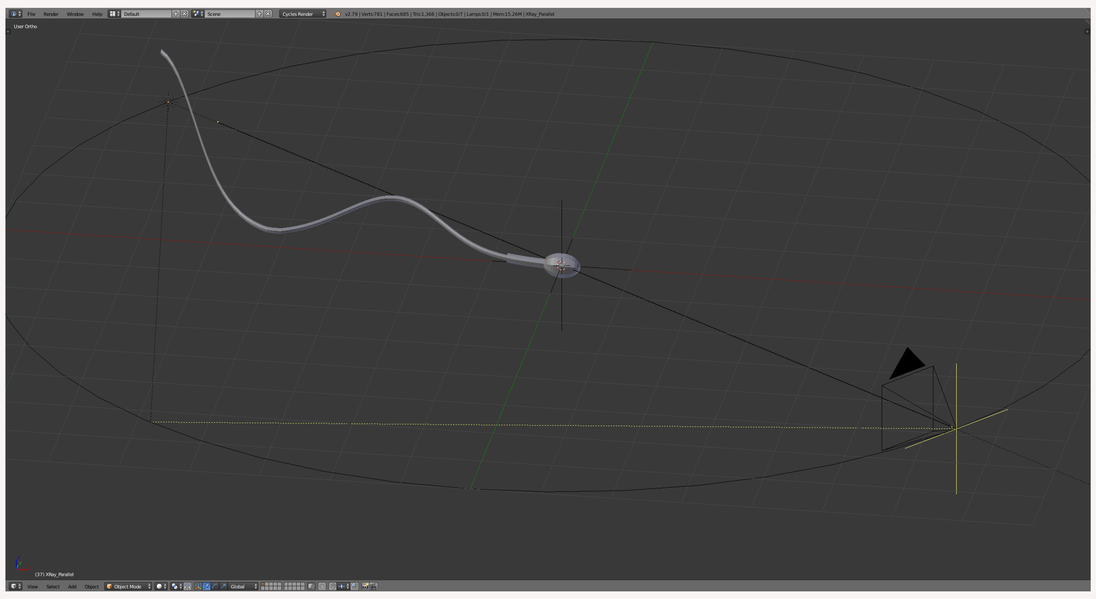
Sperm motility is declining



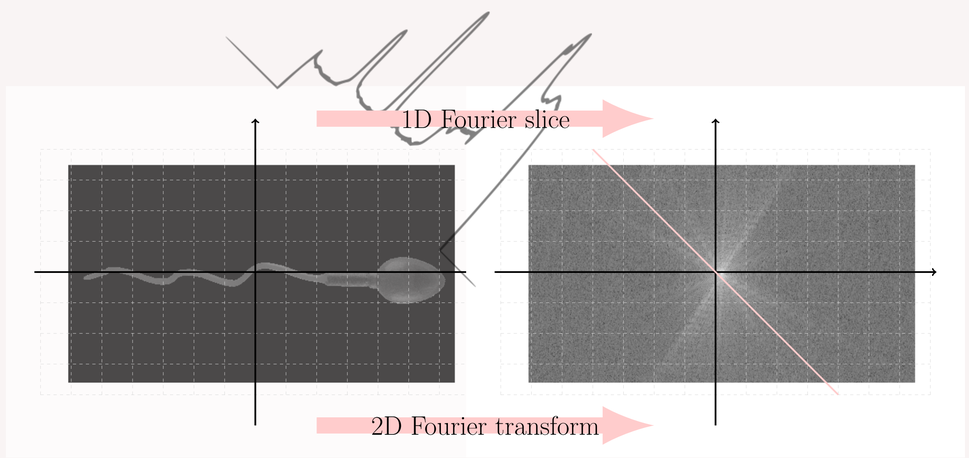
- Infertility is a growing problem [1] and WHO estimates that approximately 186 million people are affected worldwide [6].
- Approximately 40-50% of infertility cases are due to male factors [3].
- It is technically difficult to measure how fast the sperm is progressing so motility analysis is very limited [5]
- The percentage of motile sperm has been shown to significantly increase the pregnancy rate [2] and is also a major determinant in intrauterine insemination treatment [7].

In order for doctors to learn more about what influences sperm motility and hence what we can do about it, it would be beneficial for them to see how sperm cells move in three dimensions. It is my hopes that using 4D tomography will help doctors at Rigshospitalet find out why sperm motility is declining by letting them see exactly how different factors influence how sperm cells swim to reach the egg.

Reconstructing a spermatozoa from synchrotron images



The starting point for the project has been to develop a 4D phantom. This was done using Blender and Python.



Methods based on the fourier slice theorem and the radon transform are fast and efficient for 2D and 3D reconstructions.

Original

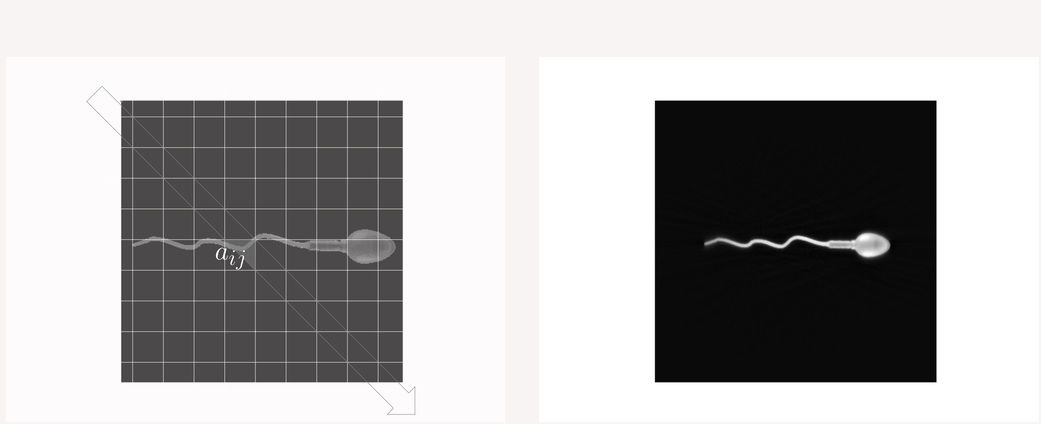
Sinogram

FBP 180 angles

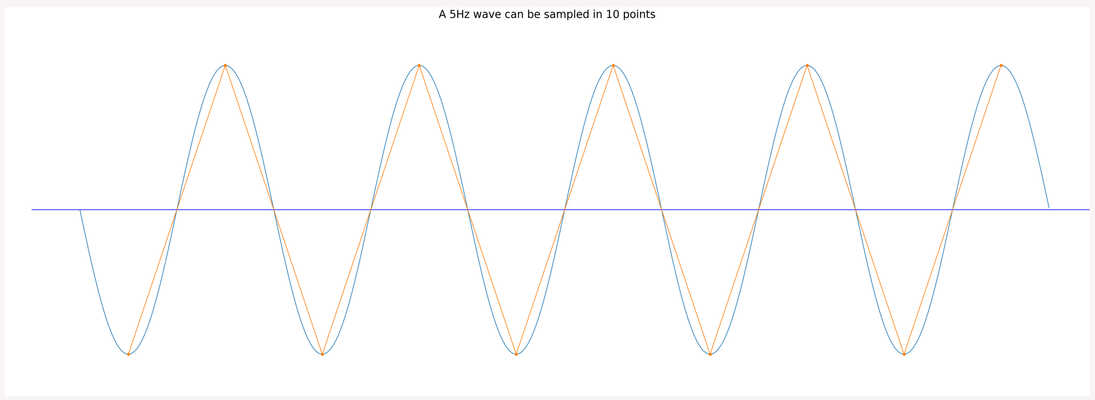
FBP 50 angles

ART 50 angles

Movement artifacts



Algebraic reconstruction methods, where the problem is reduced to solving a linear system of equations are generally slower but more flexible.



The sperm cell rotates at approximately $5Hz$, hence at least 10 3D frames per second are needed to reconstruct the rotation. For one 3D frame approximately 180 projection angles are needed for a nice artifact free reconstruction. For a 5 second 4D reconstruction this results in the amount of data adding up to 50 sinograms. If we assume we're using a 512×512 pixel detector then each sinogram is a 3D matrix of size at least $512 \times 512 \times 180$. This is a huge amount of data, so optimization techniques are definitely needed to speed up the reconstruction.
Generally there are two problems with the amount of data needed. One is the computation time, the other is the amount of radiation required which will most likely influence the movement of the spermatozoa. For this reason limiting the number of angles needed for a good reconstruction is paramount.

Acknowledgements and references

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References

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