Ansys + Optotune

CASE STUDY

/ Using Simulation and Liquid Lenses for Early Melanoma Detection

Skin cancer is the most common cancer in the United States, with roughly 5 million people treated every year. In an effort to make early melanoma detection easier and more efficient, the European Union's Horizon Europe program provided funding for the Intelligent Total Body Scanner for Early Detection of Melanoma (iToBoS) project.

Partners working on iToBoS are developing an artificial intelligence (AI) diagnostic platform to help detect melanoma. The platform includes a total body scanner and computer-aided diagnosis (CADx) tool to integrate patient-specific data. The total body scanner will be based on an existing prototype developed by three of the project partners and powered by **Optotune's** high-resolution cameras equipped with liquid lenses. Based on two immiscible fluids of different refractive indexes, these novel lenses provide unprecedented image quality of the whole body. The integration of images with all available patient data using machine learning will lead to a new dermoscopic diagnostic tool that can provide prompt, reliable, and highly personalized diagnostics for optimal judgment in clinical practice.

/ Challenges

The iToBoS construction is similar to an MRI or CT scanner. The patient lays on a bed with five arches above them. Each arch has three camera modules that can move laterally and vertically. Each camera module has a:

- High-resolution camera
- Objective lens
- Lighting system
- Distance sensor

The lenses had a few parameters they needed to meet in addition to technical specifications.

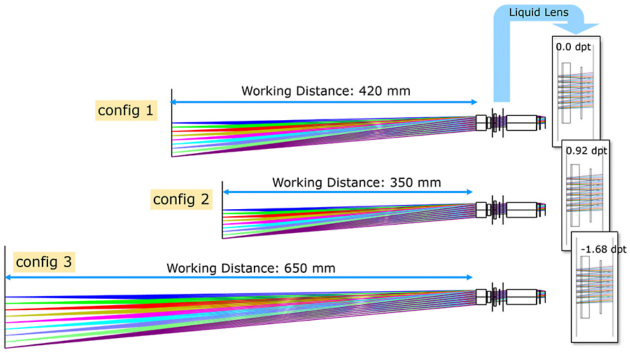
- Camera distance for patient safety — roughly half a meter
- Scanner time for patient comfort — typical MRIs take anywhere from 20 minutes to over an hour
- Small field of view (FoV) for high resolution images — the distance between the camera and patient requires smaller FoVs for the same image quality as if the camera was a few centimeters away.
- Small depth of field (DoF) to account for the 3D object, the patient — stack several images by moving the focus in small steps

/ Technology Used

- Ansys Zemax OpticStudio® optical system design and analysis software

/ Engineering Solution

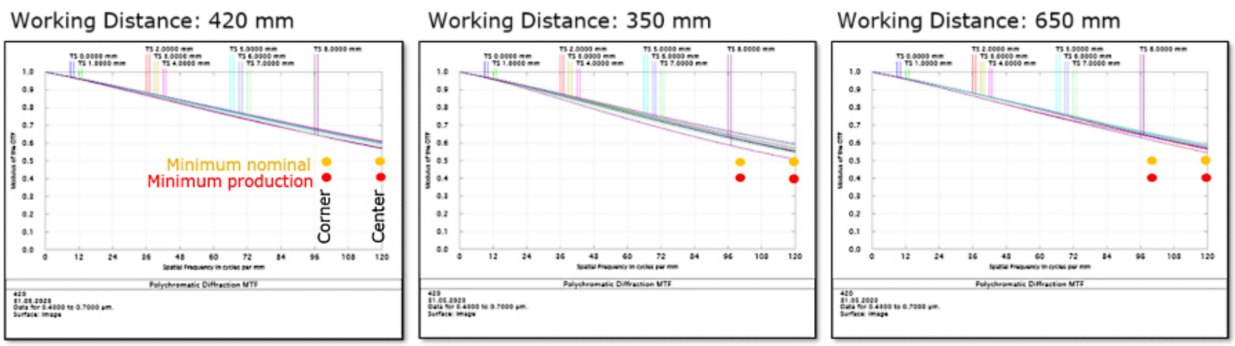
To test the different lens requirements, Optotune turned to **Ansys Zemax OpticStudio software**. When using a liquid lens in an optical design, it needs to be dynamic. In this case, Optotune needed to adjust the distance between the patient and the camera module (called the working distance) from 350 to 650 mm, with an intermediate distance of 420 mm. Unlike other lenses, a liquid lens does not need to undergo a large change in focal power (+1 diopter to -1.7 diopters) to adjust the focus according to these different working distances.



Nominal design of scanner camera with liquid lens simulated in Ansys Zemax OpticStudio software

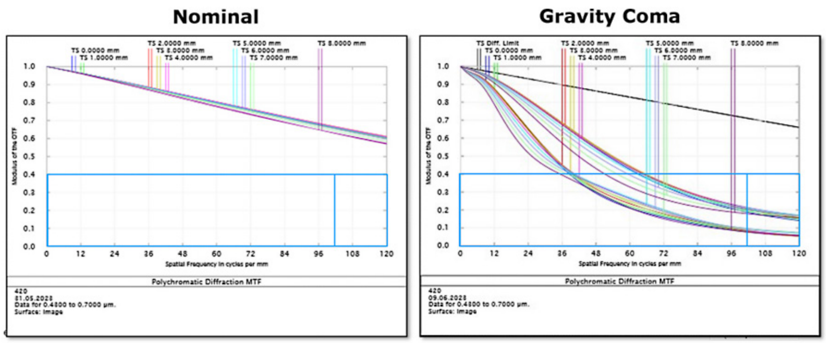
The change of the curvature of the liquid lens to adjust the focal strength is minimal compared to the adjustment a fixed lens would make in its own operating environment.

The performance of the lens required distortion of less than 1.5% and relative illumination greater than 70%. At all three distances, the lens achieved a distortion rate less than 1% and a relative illumination of 95%, even in the corners. In the image below, the orange dots represent the nominal quality Otoptune wanted to achieve. The red dots represent the minimum production quality. The nominal design is well above the target specifications. However, they were tricky to meet because the required optical quality of the iToBoS is so high.

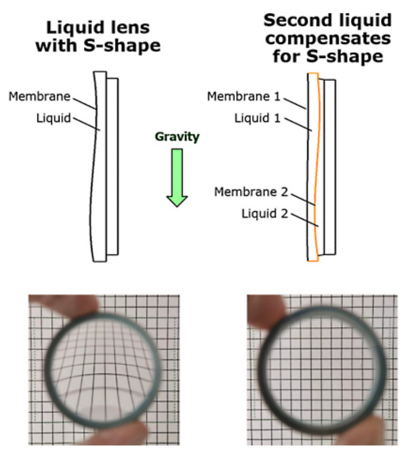


After determining the nominal design, Optotune simulated the real performance of the lenses. Since liquid lenses have liquid inside, Optotune had to account for the effect gravity would have on the lens. When a lens is held vertically, the liquid inside the lens pools at the bottom, creating what's known as coma. In human eye, coma is small enough to not affect our vision, but optics are so sensitive that coma can affect resulting images. In most cases, this type of error is negligible, but it does matter to doctors trying to determine if a mole or pigmentation is a melanoma.

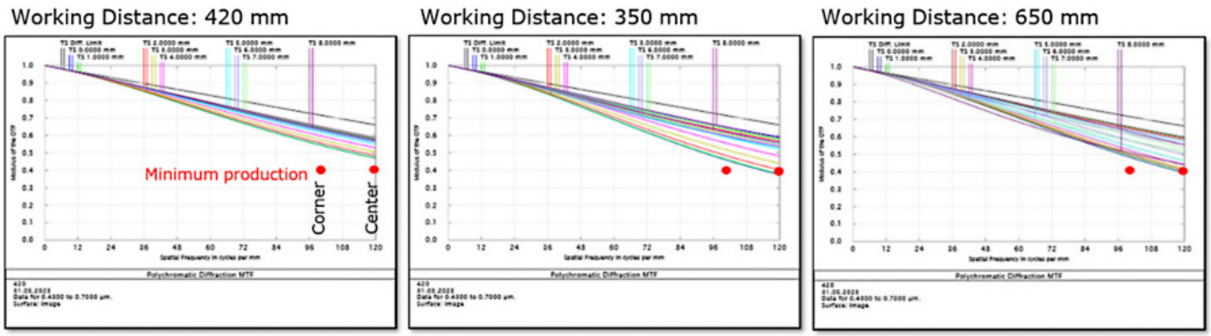
Optotune simulated the effect of gravity on their lenses in OpticStudio software. Below, you can see the nominal design results on the left and the impact of coma on the performance on the right. The results are no longer within the accepted limits indicated by the blue boxes.



To compensate for the effect of gravity on extremely sensitive optics like the iToBoS, Optotune created gravity-compensated (GC) lenses. These lenses use the same technology as regular liquid lens, but they contain two membranes and two liquids instead of one.



After implementing the GC lens for the iToBoS, Optotune simulated maximum residual coma caused by gravity and maximum allowed astigmatism of the lenses. While the GC lenses compensate for nearly all gravity-caused coma, there will always be some left over due to manufacturing tolerances. Optotune lenses have incredibly low high-order aberrations, but some magnitude of low-order aberrations like astigmatism will appear. After simulating this worst-case scenario in OpticStudio software, the Optotune team determined that the lenses still meet the minimum acceptable parameters for all three distances, as seen below.



Benefits

- Accurately simulated working distances for three different parameters
- Determined the effect of gravity comma on the liquid lens and how to compensate for it to meet the required specifications
- Compared the simulated results from OpticStudio software and actual results from scanner and the results were comparable

Company Description

Optotune develops and manufactures industry-shaping active optical components that enable customers around the globe to innovate. Founded in 2008, they started out with their core technology of focus-tunable lenses, which was inspired by the working principle of the human eye. Laser speckle reducers, 2D mirrors, tunable prisms, and beam shifters are further additions to their product lines. Thanks to their deep understanding of optics and mechanics and a passion for technology, Optotune is an ideal partner when it comes to solving challenges where conventional optics fail.

ANSYS, Inc.
Southpointe
2600 Ansys Drive
Canonsburg, PA 15317
U.S.A.
724-746-3304
ansysinfo@ansys.com

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