Scanning Method For Uniform, Normal-Incidence Imaging Of Spherical Surface With A Single Beam

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SUMMARY

UCLA researchers have created a method that achieves uniform normal-incident illumination of a spherical surface by first projecting the sphere onto a Cartesian plane and then raster scanning it using an illuminating beam. This allows the scanned object, the illumination source, and the detector to remain stationary.

BACKGROUND

Scanning of objects is commonly performed using the raster scanning method, wherein a single illumination beam sweeps across the object left-to-right, and then immediately moves to the start of the next line. Single beam scanning using this method requires that the object is planar, which limits its application to curved objects. Curved focal plane arrays have been developed to scan curved objects, but this technique cannot achieve uniform illumination across the entire object without expensive mechatronics that can move both the illumination source and detector in perfect synchrony across the curved object.

As an example, terahertz radiation (0.1 to 10 THz) has low interference, non-ionizing radiation, and high sensitivity and specificity to tissue water, which makes it an attractive technique for the diagnosis of several pathologies. Conventional terahertz imaging systems scan an object by translating the object beneath a fixed terahertz illumination beam. The inability of conventional terahertz imaging setups to scan fixed objects is a particular problem for scanning spherical objects such as the eye. The ability to uniformly scan a spherical surface with an arbitrary curvature while keeping the sphere, illumination source, and detector fixed would be highly advantageous for a number of challenging applications.

INNOVATION

Professors Zachary Taylor and Warren Grundfest from the UCLA Department of Bioengineering have developed a novel method to image a spherical surface with a single beam that allows the illumination source, the detector, and the sample to remain stationary. The method uses an off-axis parabolic (OAP) mirror to project a spherical surface on to a Cartesian plane. The illumination beam is then used to raster scan the Cartesian plane projection of the spherical surface. The illuminating beam is guided parallel to the optical axis of the OAP mirror using a planar scanning mirror, and is then focused towards the targeted surface at normal incidence. Since the angle of incidence of the illuminating beam is normal to the targeted surface, the reflected beam will retrace the path of the illuminating beam. The illuminated and the reflected beams are co-located using a Michelson interferometer to split the two beam paths, and are then captured by a detector to create a reflectivity map of the spherical surface. The final reflectivity map is produced as a planar image of a spherical surface similar to the Mercator projection of the globe.

APPLICATIONS

This system can be implemented with an imaging system that uses an illumination at any frequency bandwidth as long as the illumination can be collimated.

This technology can be used for terahertz imaging systems for applications such as monitoring corneal hydration in a number of clinical conditions:

- Corneal endothelial edema associated with trauma or any eye surgery
- Fuch’s dystrophy
- Glaucoma

CONTACT

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INVENTORS

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OTHER INFORMATION

KEYWORDS

Imaging, beam scanning, curvature, curved surface, spherical surface, terahertz, off-axis parabolic mirror, cornea, eye, conservation, non-invasive

CATEGORIZED AS

- **Optics and Photonics**
  - All Optics and Photonics
- **Imaging**
  - Medical
  - Other
- **Medical**
  - Disease: Ophthalmology and Optometry
  - Imaging
  - Other
  - Research Tools
- **Research Tools**
  - Other
- **Sensors & Instrumentation**
  - Medical
  - Scientific/Research

RELATED CASES

2015-150-0

- Iritis
- Cornea transplant rejection
- Keratoconus

By allowing the sample to remain stationary, it can also be used in art and archaeological materials conservation and research as a non-ionizing, noninvasive, noncontact, nondestructive imaging tool (including terahertz imaging).

ADVANTAGES

- Achieves a uniform illumination of the spherical surface
- Achieves a normal incidence across the entire object surface
- Can scan an object while keeping the object, illumination source, and the detector fixed

RELATED MATERIALS

- Taylor ZD, Garritano J, Sung S, et al. THz and mm-Wave Sensing of Corneal Tissue Water Content: In Vivo Sensing and Imaging Results. IEEE transactions on terahertz science and technology. 2015;5(2):184-196.

PATENT STATUS

Country	Type	Number	Dated	Case
Germany	Issued Patent	EP 3265863B	12/08/2021	2015-150
European Patent Office	Issued Patent	EP 3265863B	12/08/2021	2015-150
France	Issued Patent	EP 3265863B	12/08/2021	2015-150
United Kingdom	Issued Patent	EP 3265863B	12/08/2021	2015-150
United States Of America	Issued Patent	10,517,477	12/31/2019	2015-150
Hong Kong	Published Application	1248826A	10/19/2018	2015-150

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Simultaneous Corneal Hydration Thickness And Hydration Measurement Through Multi-Spectral Reflectometry
- Assessment Of Wound Status And Tissue Viability Via Analysis Of Spatially Resolved Thz Reflectometry Maps

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