

SH-ToF: Micro Resolution Time-of-flight Imaging with Super-heterodyne Interferometry

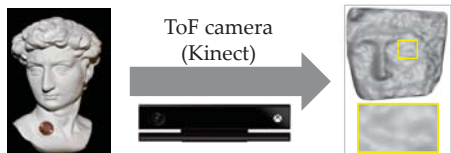
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MOTIVATION

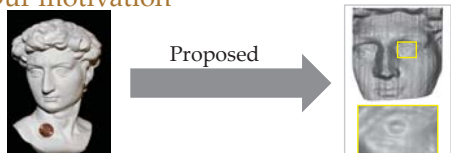
Why ToF cameras for 3D imaging?

- Large baseline for comparable depth resolution (Triangulation based 3D imaging e.g. structure light camera)
- ToF camera's compact size

Problem with current ToF cameras



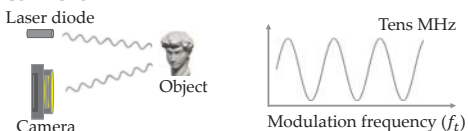
Our motivation



- Build a depth camera with micro resolution

BACKGROUND & PROPOSED

ToF camera



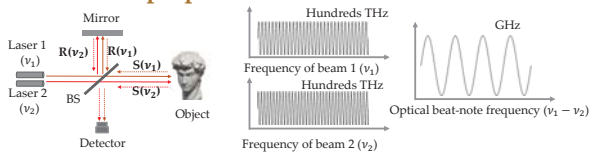
- Meters image range but centimeters depth resolution

Michelson Interferometry (MI)



- Micro depth resolution but micro image range
- Not able to image optical rough surface (laser speckle)

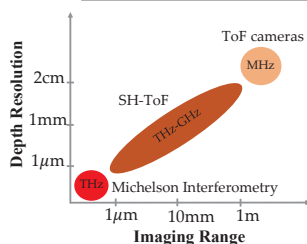
SH-ToF (Our propose)



- Micro depth resolution but tunable image range (micro to meters)
- Able to image optical rough surface (laser speckle)

COMPARISON & CONTRIBUTIONS

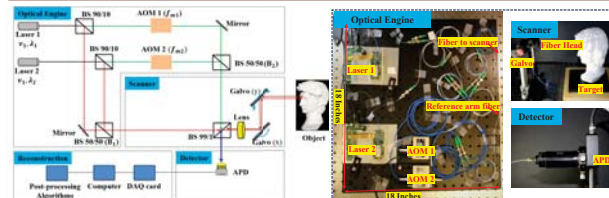
ToF camera	MI	SH-ToF
$z = \frac{1}{2} \frac{c}{f_i} \frac{\phi_p}{2\pi}$	$z = \frac{1}{2} \frac{c}{v} \frac{\phi}{2\pi}$	$z = \frac{1}{2} \frac{c}{(v_1 - v_2)} \frac{\phi}{2\pi}$
100 MHz	100 THz	1GHz-1THz



Our Contributions

- Micro resolution
- Tunability between depth resolution and depth range
- 3D scanning on rough surface

PROTOTYPE

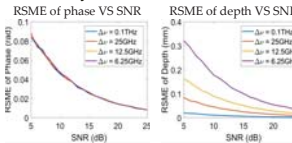


QUANTITATIVE EVALUATION

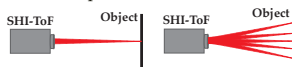
Pixel-point measurement

Δv [GHz]	100	25	12.5	6.25
$\delta\Phi$ [rad]	0.041	0.049	0.059	0.047
δz [mm]	0.009	0.047	0.114	0.179

Physical based simulation

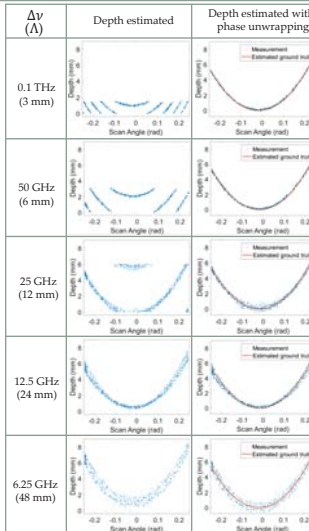


Setup



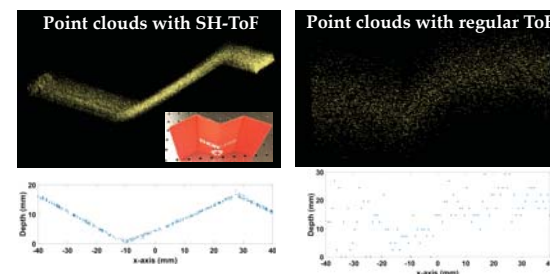
Line-scan measurement

Δv [GHz]	100	50	25	12.5	6.25
δz [mm]	0.070	0.093	0.221	0.274	0.437

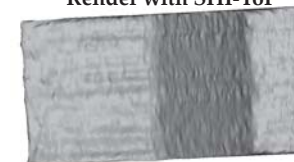


3D SCANNING

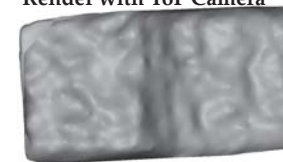
Folded cardboard



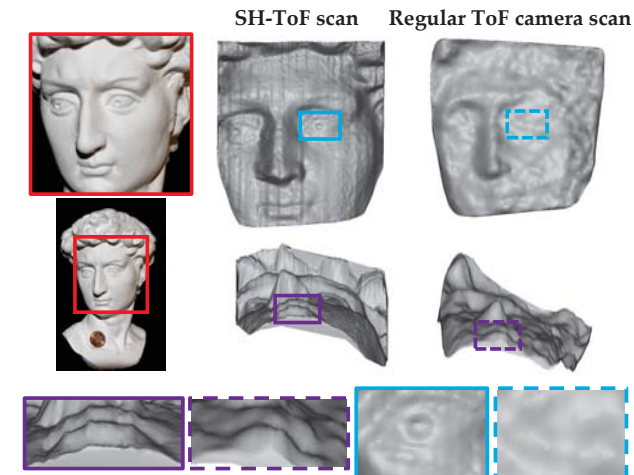
Render with SHI-ToF



Render with ToF Camera



Plaster bust



ACKNOWLEDGEMENT

