OptoSkin: Touch Localization with Time-of-Flight Measurements

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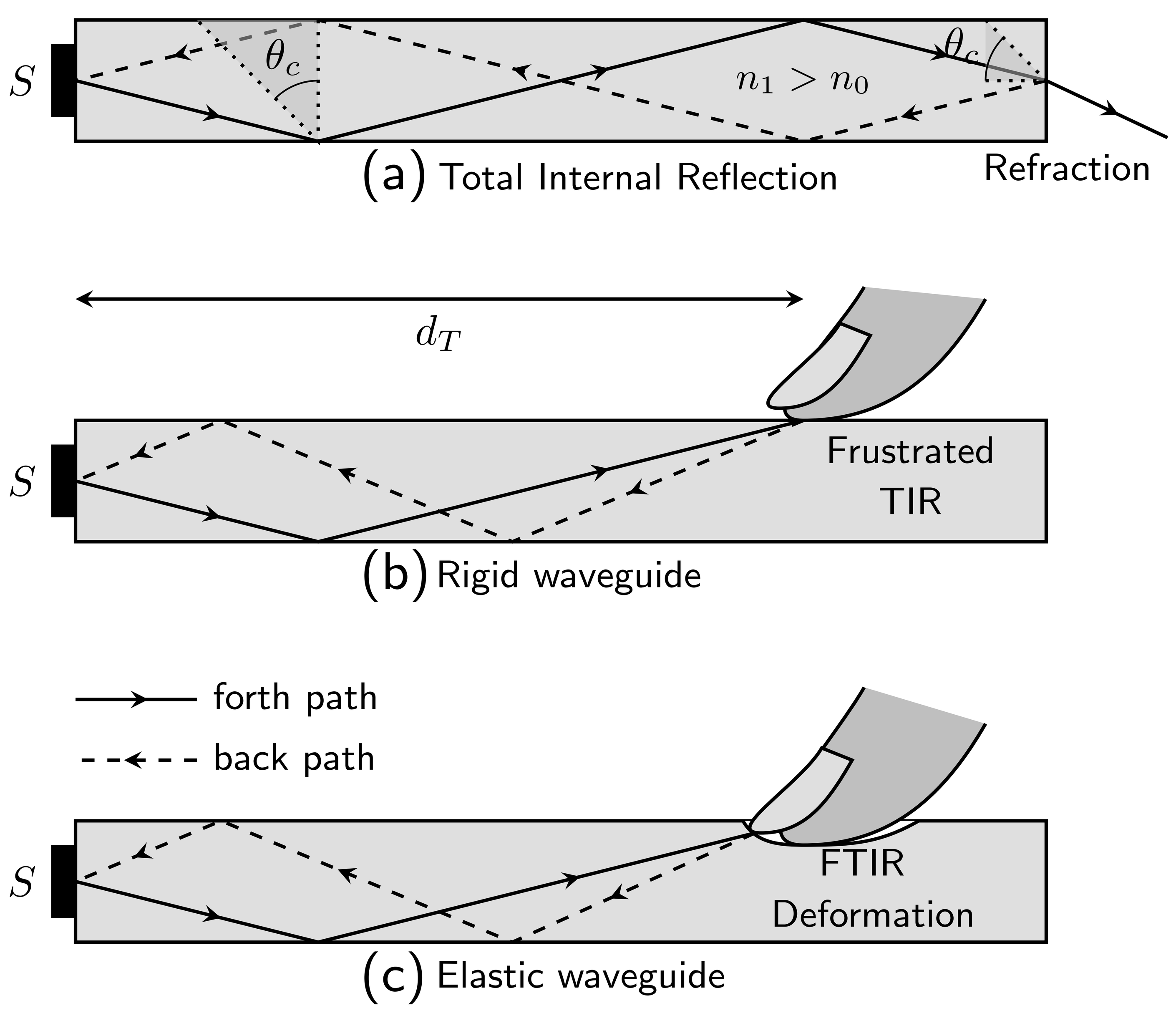
We propose OptoSkin, a novel type of sensor for touch and pressure detection based on direct Time-of-Flight (dToF) measurements of light propagated within waveguides due to Total Internal Reflection (TIR). It is compact, cheap and easy to fabricate, showing great potential for multi-touch systems, like interactive screens or robotic tactile skins.

Working principle



In OptoSkin, light travels through the waveguide by (a) **Total Internal Reflection** ($n_0 < n_1$). In the touched area, light is reflected by (b) interaction of light with environment ($n_2 \neq n_0$) through **Frustrated Total Internal Reflection** (FTIR) conditions e.g. scattering from skin ($n_2 \approx n_1$), and due to (c) deformation (elastic material) of the waveguide surface.

Distance to the touch point when refractive index $n_0 = 1$ (e.g., air):

$$d = \frac{(t_{touch}\ c)}{2}$$

Incident angle θ_1 of TIR is $\geq$ than the critical angle θ_c (based on the Snell's law):

$$\theta_1 \geq \theta_c = arcsin\frac{n_1}{n_0}$$

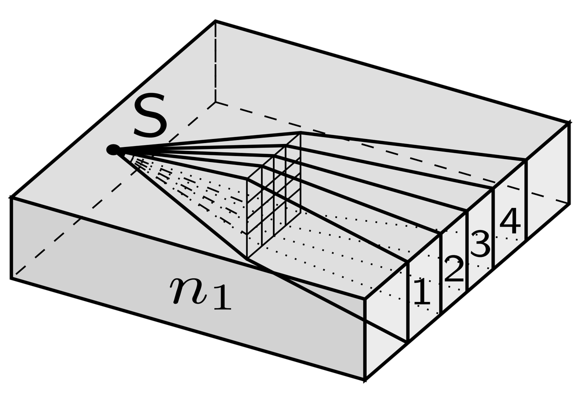
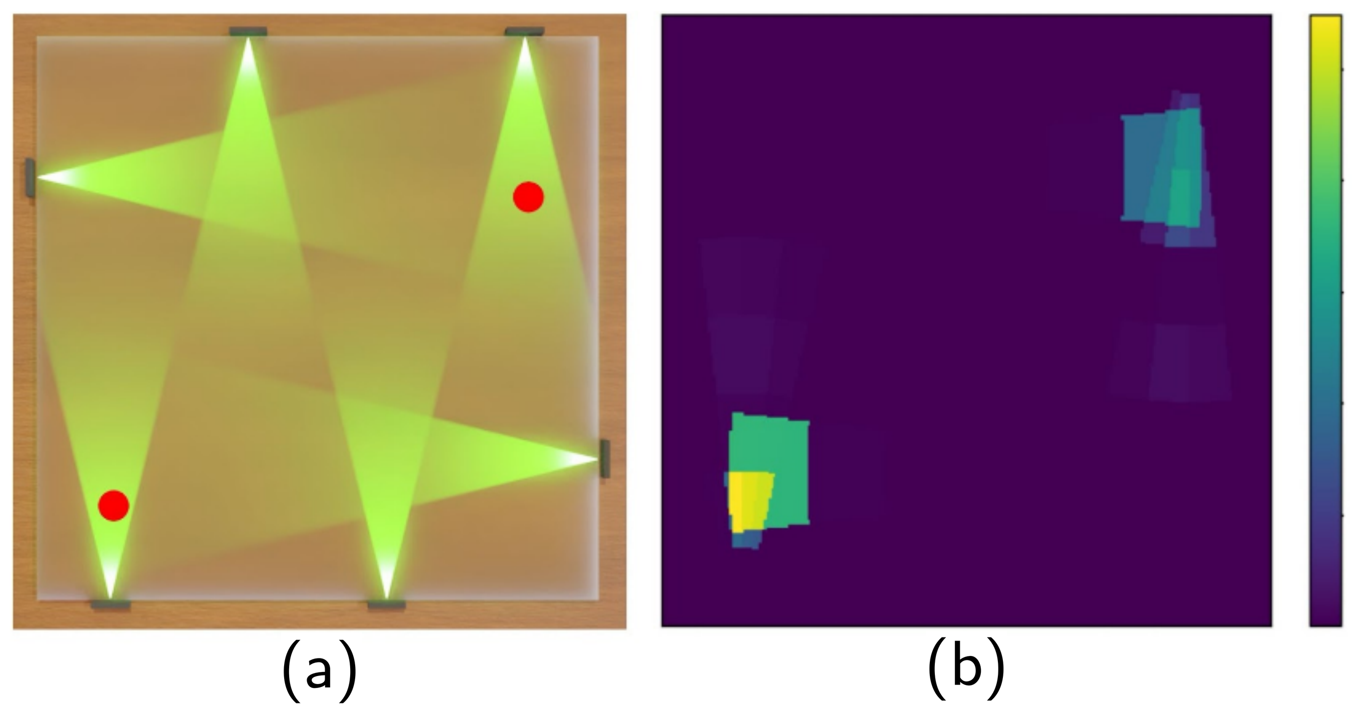


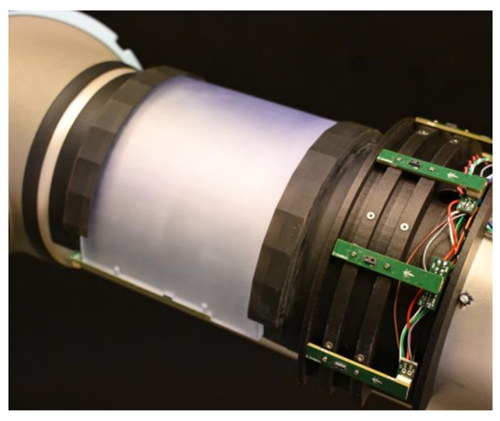
Illustration depicting the field of view (FoV) of the ToF sensor within an optical waveguide.

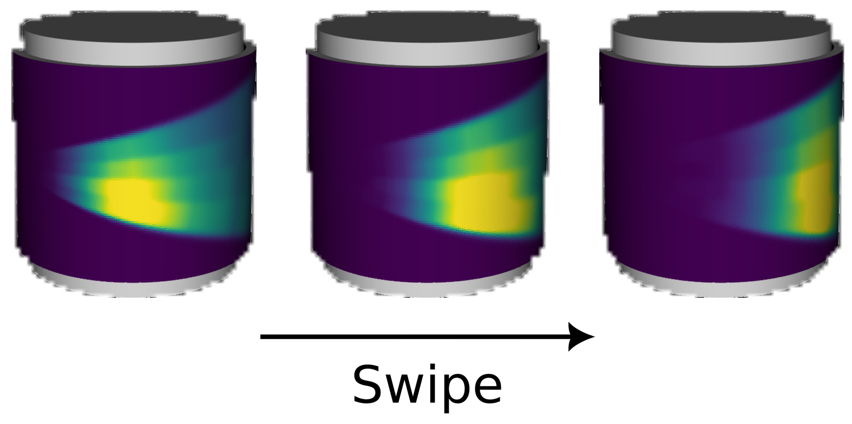
Simulations



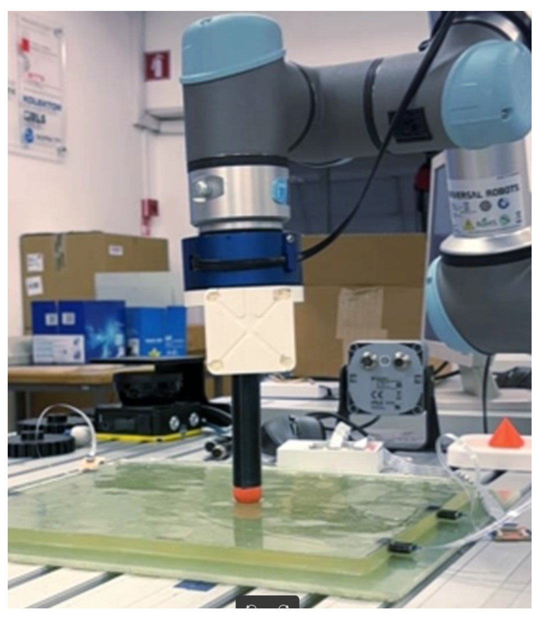
(a) A digital twin of the OptoSkin setup with six ToF sensors and two touches on the red circles. (b) We simulate light transport inside the waveguide. From the simulated ToF signal, we reconstruct the two touch locations by triangulating the ToF of the light

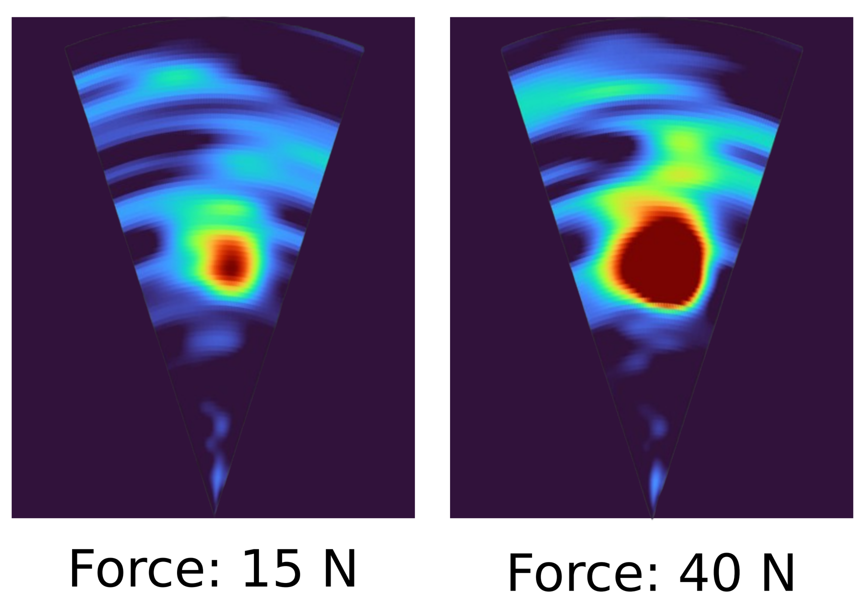
Prototypes





Real OptoSkin prototype fabricated using a rigid waveguide realized with 3D printed material (CrystalClear ring of Monocure3D). We show the reconstruction of swipe.





Real OptoSkin prototype fabricated using a soft (deformable) waveguide made from silicone rubber to sense the location and applied force of touch.

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