

1. Problem and Motivation

Existing hand tracking solutions are limited in accuracy, robustness or both.

	Mocap	Sensor	Video
Accuracy	High	Medium	Low
Availability	Low	Medium	High
Occlusion	Medium	Medium	High

A shape sensing optical fiber is:

- Highly accurate
- Robust to interference

and could serve as a good sensor for hand tracking purposes.

2. Background – Shape Sensing Optical Fiber

Sensors (Fiber Bragg Gratings, FBGs) embedded in optical fiber reflect wavelengths w.r.t. fiber strain.

$$\Delta\lambda \sim \epsilon + \Delta T$$

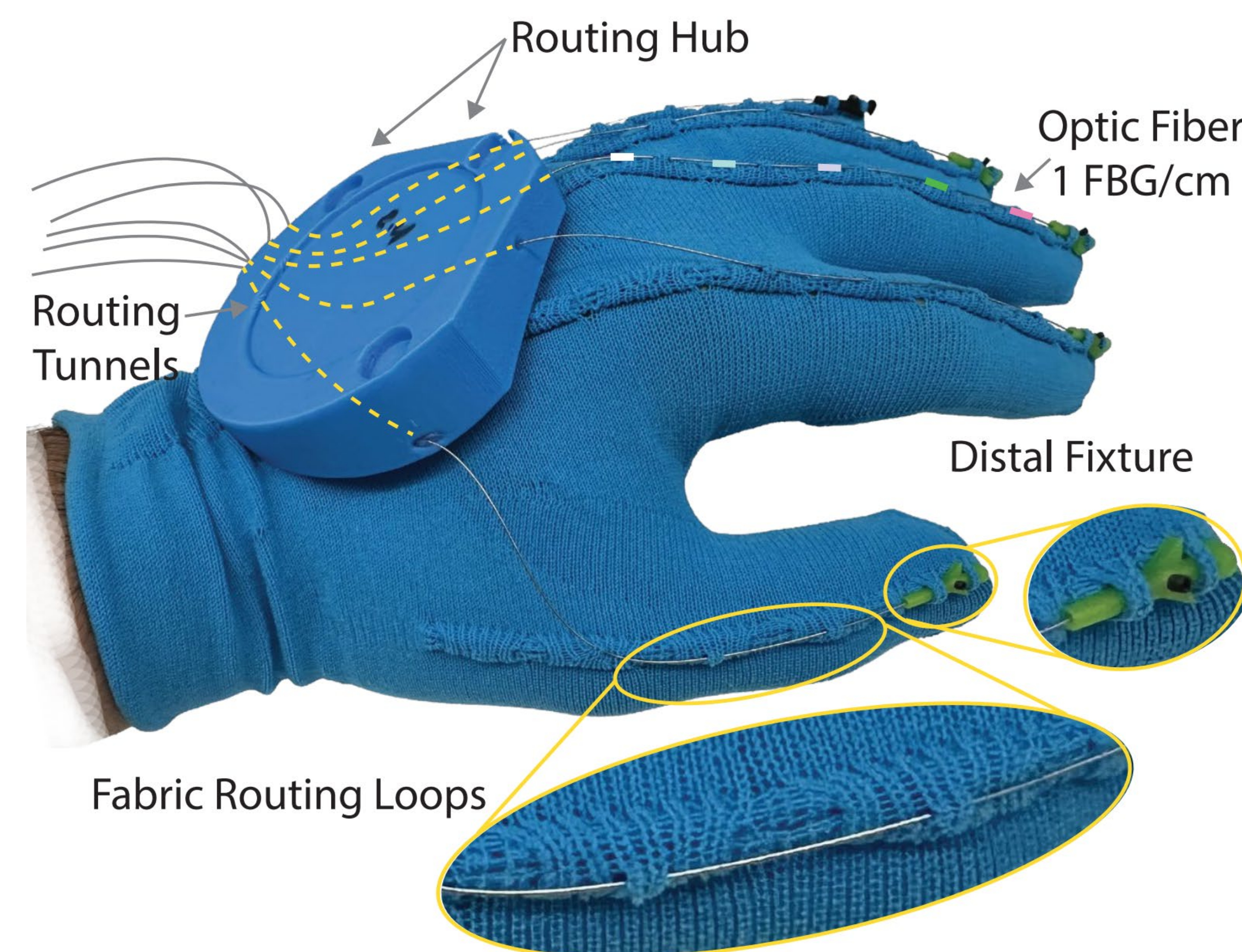
Reflected Wavelength Strain Temperature

Previous work has used single-core fibers routed along fingers, placing sensors directly over joints [1].

In contrast, our work uses multi-core fiber with dense FBG placement to **reconstruct 3D fiber shape** along the 26 cm sensing region.

Multi-core fibers measure curvature and bend direction every 1 cm, which are integrated to reconstruct shape.

3. System Design



4. Hand Pose Reconstruction

An efficient registration algorithm matches fiber shapes to a common routing hub.

Shape Registration

Routing Hub

Tunnel Matching

Fibers in Local Frame

Fibers in Hub Frame

Inverse Kinematics

Routing Hub

Spline Constraint

Distal Direction Constraint

The hand model is fit to follow the fiber using physical constraints and an inverse kinematics solver.

Registration + solver run at 60 Hz.

5. Dataset and Accuracy

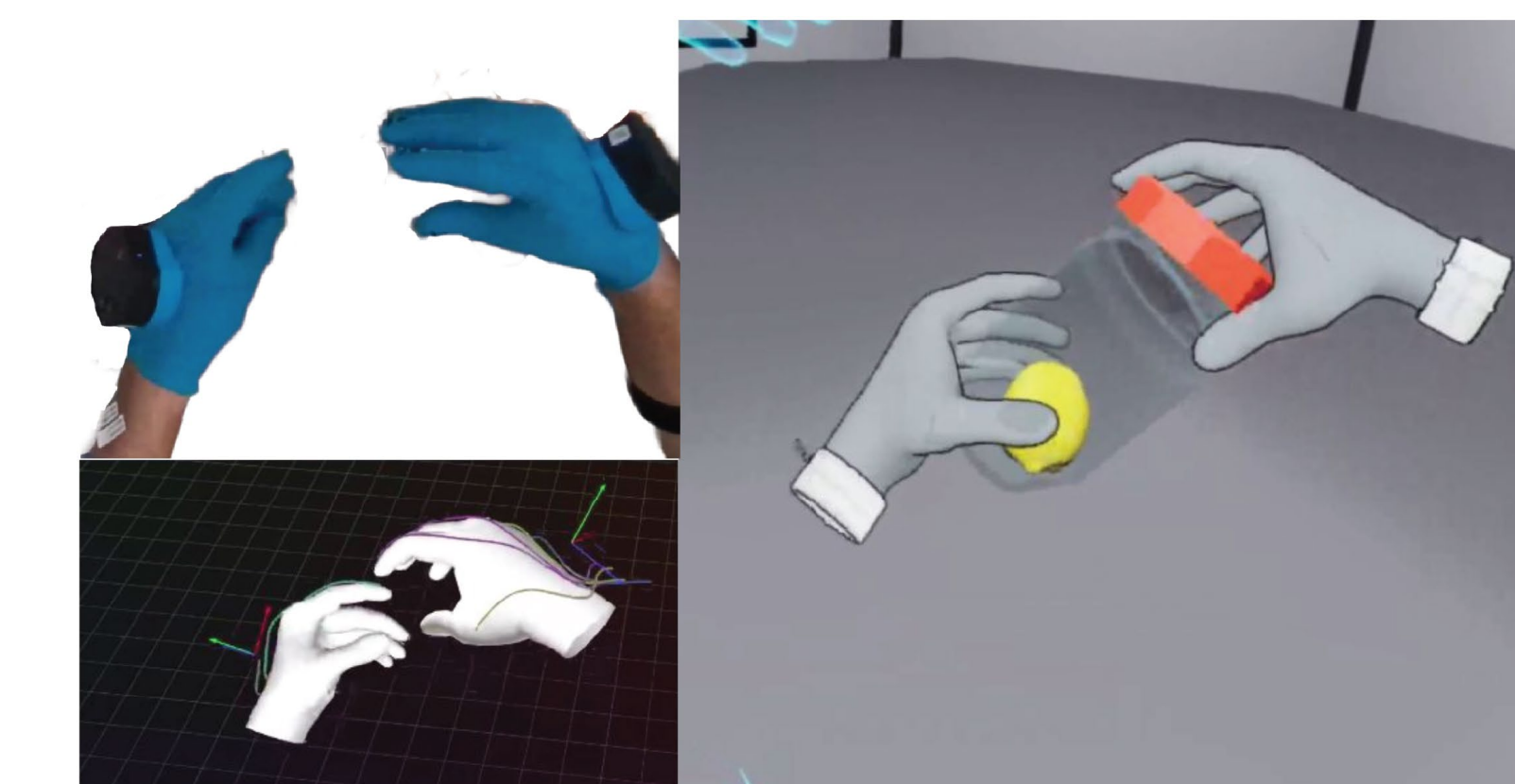
We collect a 2-hour, 5-subject, multi-session dataset of participants performing dexterous manipulation of several objects. We use reflective markers on the glove as our ground truth (Mocap) [2].

We find that the shape registration step produced consistent errors in fiber placement, and that a **one-time calibration** reduced fingertip error.

Mean Keypoint Error (MKPE) and Fingertip Error (F.MKPE) decrease with tunnel alignment.

	MKPE (mm)	F.MKPE (mm)
Base	5.9	7.2
Tunnel Aligned	4.4	4.9

Real time tracking enables **teleoperation**.



6. Occlusion Robustness

A simple cup grasp or self-occlusion can cause mocap to fail.

34% of frames had at least one mocap marker occluded, while our method only fails under extreme fiber bending, which did not occur.

7. Conclusion

	Ours
Accuracy	High (<5 mm error)
Availability	Medium/High (Cables)
Occlusion	Low (not observed in dataset)

Self Occlusion

Object Occlusion

Glove

Glove Reconstruction

Marker-Based Mocap