DIGIT Pinki Quick Start Guide

1. Introduction

DIGIT Pinki is a compact, high-resolution tactile sensor suitable for operation in constrained spaces, such as medical palpation tasks. DIGIT Pinki uses optical fiber bundles to miniaturize the form factor of the sensing element significantly. This guide details the manufacturing, assembly, and quick start instructions for the DIGIT Pinki tactile sensor.

We recommend using the following printer settings for 3D-printed parts:

Component	Specification
3D Printer	Stratasys J750
Layer Height	Default
Material	Vero Black Plus
Finish	Glossy

2. Distal Sensing Element Manufacturing

List of materials needed for making the elastomer gel and distal sensing element:

Part Number	Description	Quantity
1	DIGIT Gel Mold	1
2	Vacuum degas chamber	1
3	Smooth-on Solaris Shore 10A	1
4	Smooth-on InhibitX	1
5	Smooth-on Ecoflex 00-10	1
6	Smooth-on Silc-Pig White	1
7	Smooth-on NOVOCS Matte	1
8	Smooth-on Ease Release 200	1

9	Rustoleum Mirror Effect Spray	1
10	99% Isopropyl Alcohol	1
11	Nitrile Glove	2
12	Cups	2
13	Wooden Mixing Sticks	2
14	Digital Scale	1

To create the mold for the elastomer gel, one may either machine a metal mold or create a daughter mold. If you choose to machine the mold using the provided mold file (recommended), skip to Section 2.2. If you choose to create a daughter mold, go to Section 2.1.

2.1. Gel Daughter Mold

This section details how to create a daughter mold using silicone from a blank copy of the desired gel shape.

Materials needed in addition to the above material list:

- 1 pint unit of Mold Star 16
- 3D-printed or machined DIGIT Pinki gel shape

1. Clean the DIGIT Pinki gel shape with 99% isopropyl alcohol and place into a clean mold container, such as a cup or a box.
    a. Use a silicone mold release on mold container if needed, letting outgas for 15-30 minutes after spraying.
    b. Using mold release on the gel shape will create surface texture, so we recommend using a 3D-printed or machined gel shape.
2. Mix Mold Star 16 using 1:1 Part A to Part B by weight ratio, using the digital scale. After mixing well, pour mixture over the mold container until the Mold Star silicone fully encapsulates the gel shape.
3. Place in a vacuum degas chamber and vacuum 1 - 3 cycles at -85 kPA until there are no bubbles in the mold
4. De-mold the daughter mold from the container once Mold Star has cured after 4+ hours

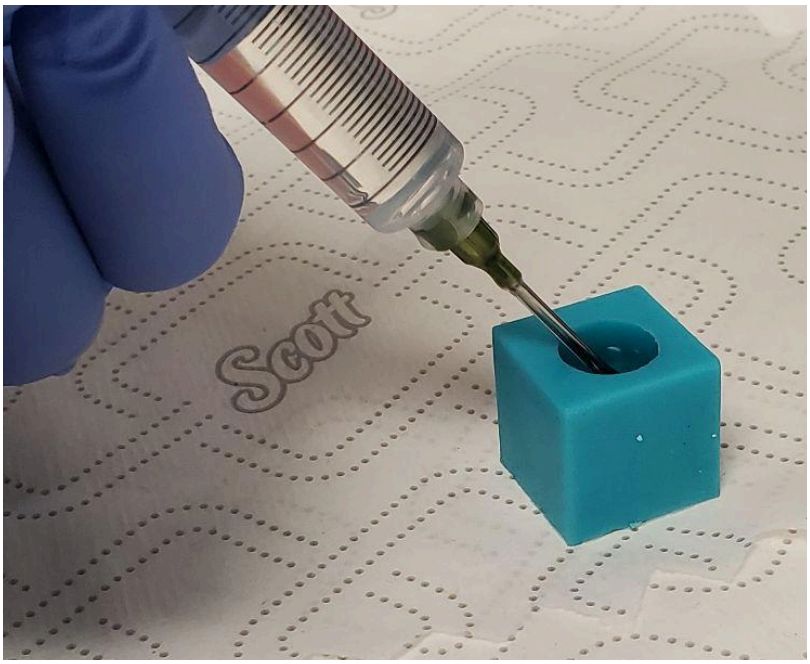
2.2. Gel Base

This section details how to create the elastomer gel base once a mold (either machined or silicone) has been obtained.

Optional Materials:

- (Optional) Syringes with Luer Lock tip (recommended 14 Ga size or larger)
- (Optional) KimTech wipes

1. Clean the mold with 99% isopropyl alcohol and let the alcohol dry off.
2. (Only if you are using a silicone daughter mold) Spray the mold with silicone mold release, holding the mold release spray at least 6 inches away for an even coating.
    a. Let outgas for 15-30 minutes
    b. If there is too much excess mold release, repeat steps 1 and 2 again to avoid unnecessary surface texture.
3. Using a cup and wooden mixing stick, mix Solaris using 1:1 Part A to Part B by weight ratio.
4. Place the mixture in a vacuum degas chamber and vacuum for 1-3 cycles at -85kPA until there are no bubbles in the Solaris
5. Pour the Solaris mixture into the mold cavity.
    a. (Optional) For more precision when putting the Solaris into the mold, use a syringe with a 14 Ga size or larger Luer Lock tip. Below is an image of Solaris injected into a silicone mold cavity.



6. Place the filled mold into the vacuum degas chamber and again vacuum at 1-3 cycles at -85 kPA until there are no bubbles in the Solaris gel. This is to remove any bubbles that were introduced during the pouring process.
7. Let the Solaris cure for 24+ hours at room temperature and atmosphere pressure. We recommend covering the mold to prevent any dust
8. Demold the gel from the mold.

2.3. Gel White Paint Mixture

Next, prepare the white silicone paint mixture that will coat the finished gel surface.

1. Mix Smooth-on Ecoflex 00-10 evenly with equal parts A and B.
2. Add in 3% white Silc Pig pigment by weight.
3. Dilute the white Ecoflex 0010 with NOVOCS matte 0.8% by weight. The result should have a similar consistency to liquid yogurt. You may test out the mixture and add more or less NOVOCS matte as suitable.
4. Set aside the resulting white silicone paint mixture for the final assembly step.

2.4. Gel Surface Layer Assembly

This section details how to create the surface layers on top of the optically-clear base gel.

Optional Materials:

- (Optional) Airbrush system
- (Optional) heat gun
- (Optional) Latex-free cosmetic blender wedge

1. Clean surface of the Solaris gel with 99% isopropyl alcohol

2. Coat the gel with a thin layer of InhibitX (may be airbrushed if desired).
    a. Let outgas for 15 - 30 minutes.
3. Using Rustoleum Mirror Effect, spray the gel with 3-5 horizontal passes across the entire surface until there is an even silver coating.
    a. Let dry for 15 - 30 minutes.
4. Apply another thin (may be airbrushed) layer of InhibitX
    a. Let outgas for 15 - 30 minutes
5. Using a thin wooden mixing stick, thinly drip coat the surface of gel with the white paint silicone mixture. The mixture should drip down like coating a candy surface.

a. (Optional) Use a Latex-free cosmetic foam blender wedge or a syringe to evenly distribute the white silicone if dripping is not sufficient
b. Set aside in a covered (dust-free) environment to cure for 4 hours or set using heat gun if time sensitive.

2.5. Sensing Element Assembly

With a completed hemispherical gel (with the reflective layer and protective white paint layer), we may then assemble it into the mechanical enclosure.

Part Number	Description	Quantity
1	3D-printed thread	1
2	3D-printed housing enclosure	1
3	Cyanoacrylate	1
4	Cargille Optical Gel	1

1. Using cyanoacrylate, adhere the 3D-printed thread to the base of the gel so that the gel may be screwed onto the housing enclosure.
2. Use the index-matched Cargille optical gel on the base of the gel before screwing it on.

3. Illumination System Fiber Assembly

In this section, we detail how to assemble the illumination fiber bundle.

Part Number	Description	Quantity
1	PMMA Fibers (e.g. 265µm with 48 Fiber Light Guide)	1
2	Razor blade or cutting knife	1
3	Sandpaper (180, 400, 1000 grit)	1
4	99% Isopropyl Alcohol	1
5	Cyanoacrylate (super glue)	1

6	Sil-Poxy	1
7	Neopixel Ring	1
8	3D-printed Neopixel Enclosure	1

1. Cleave fiber ends using a razor blade. If possible, use a fiber cutting block or other similar jig in order to ensure a blunt, perpendicular face
2. Polish and clean fiber ends:
    a. Use 180 grit (dry), 400 grit, and then 1000 grit (wet) sandpaper. Sand in a “Figure 8” motion for 20 passes with each sandpaper.
    b. Clean the end faces with 99% isopropyl alcohol after sanding.
3. Bundle the fibers into the fiber mount.
4. Press fit the fiber bundle into fiber mount and use sharp scissors or shears to trim to edge.
    a. Securely adhere using one drop of cyanoacrylate.
5. Adhere mount to elastomer gel through the enclosure conduits using Sil-Poxy
    a. Do not move until Sil-Poxy has cured or else the mount will delaminate
6. On the illumination side, adhere fibers to LEDs using cyanoacrylate

4. Imaging Optical Bench Setup

In this section we describe the setup used for magnifying and imaging the output from the coherent fiber bundle.

List of materials needed:

Part Number	Description	Quantity
1	Coherent Imaging Fiber Bundle with Adjustable Diopter	1
2	16MP IMX298 USB camera	1
3	10x plan Microscope objective	1
4	Microscope Eyepiece	1
5	ThorLabs Optical Metric Breadboard	1
6	ThorLabs Cage Plate Mounting Base for 30 mm Cage	1

6	ThorLabs 30 mm C-Mount-Threaded 30 mm Cage Plate	1
7	3D-Printed Custom Cage Mount for Microscope Eyepiece	1
8	3D-Printed Custom Cage Mount for Arducam	`1
9	ThorLabs 30 mm Cage System Cover	1
10	ThorLabs 6 Inch Optical Cage Rods	1
11	99% Isopropyl Alcohol	1
12	KimTech Wipes	2
13	M6 Screws	4
14	M4 Screws	2
15	(Optional) ThorLabs Cage Alignment Guide	1

1. Assemble the optical cage and optical relays:
    a. Align the 10x plan microscope objective and microscope eyepiece to the breadboard by screwing them into the C-mount cage plate and the custom 3D-printed cage plate, respectively.
    b. Secure both to the optical cage to the breadboard using the metric screws
    c. Attach the rods
    d. Remove any dust using the KimTech wipes and 99% Isopropyl Alcohol.
2. (Optional) Verify alignment visually using the ThorLabs Cage Alignment Guide
3. Then align the USB camera to one end of the optical relays, and the coherent fiber bundle to the other end of the optical relays.
4. To verify the system, plug in the USB camera to your computer and verify that you can see the fibers clearly.
    a. If the image is out of focus, manually focus the lens on the USB camera or the adjustable diopter.