Knitting Semantics
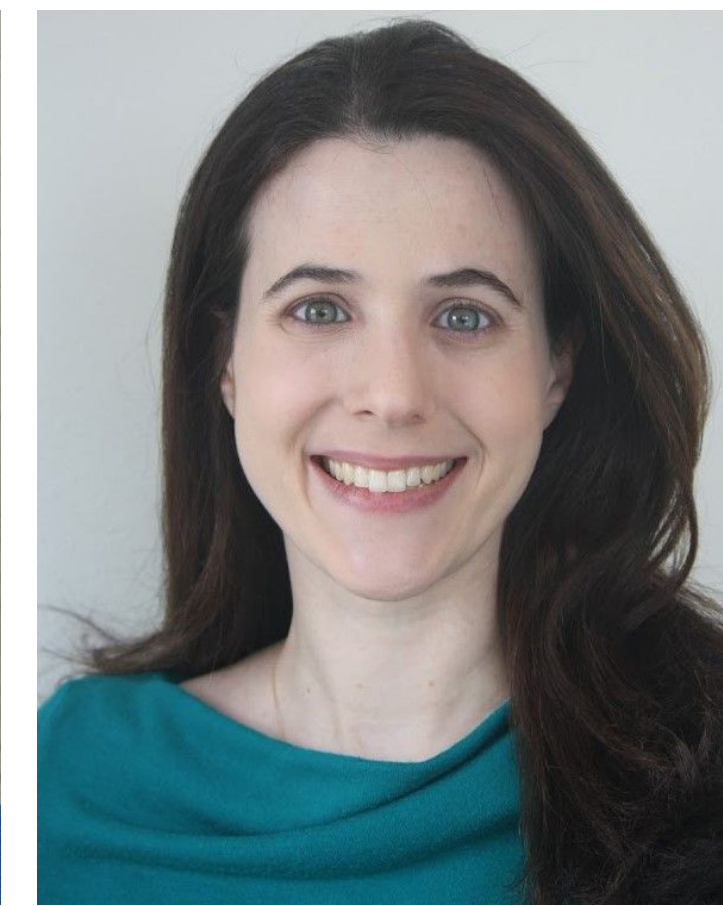
PIs: Gilbert Bernstein, Adriana Schulz, and James McCann

CMU Textiles Lab: https://textiles-lab.github.io/ Homepages: https://homes.cs.washington.edu/~adriana/ http://gilbertbernstein.com/

Knits are produced by pulling loops through loops to make stitches.

Variations allow a wide range of small and large-scale structures.
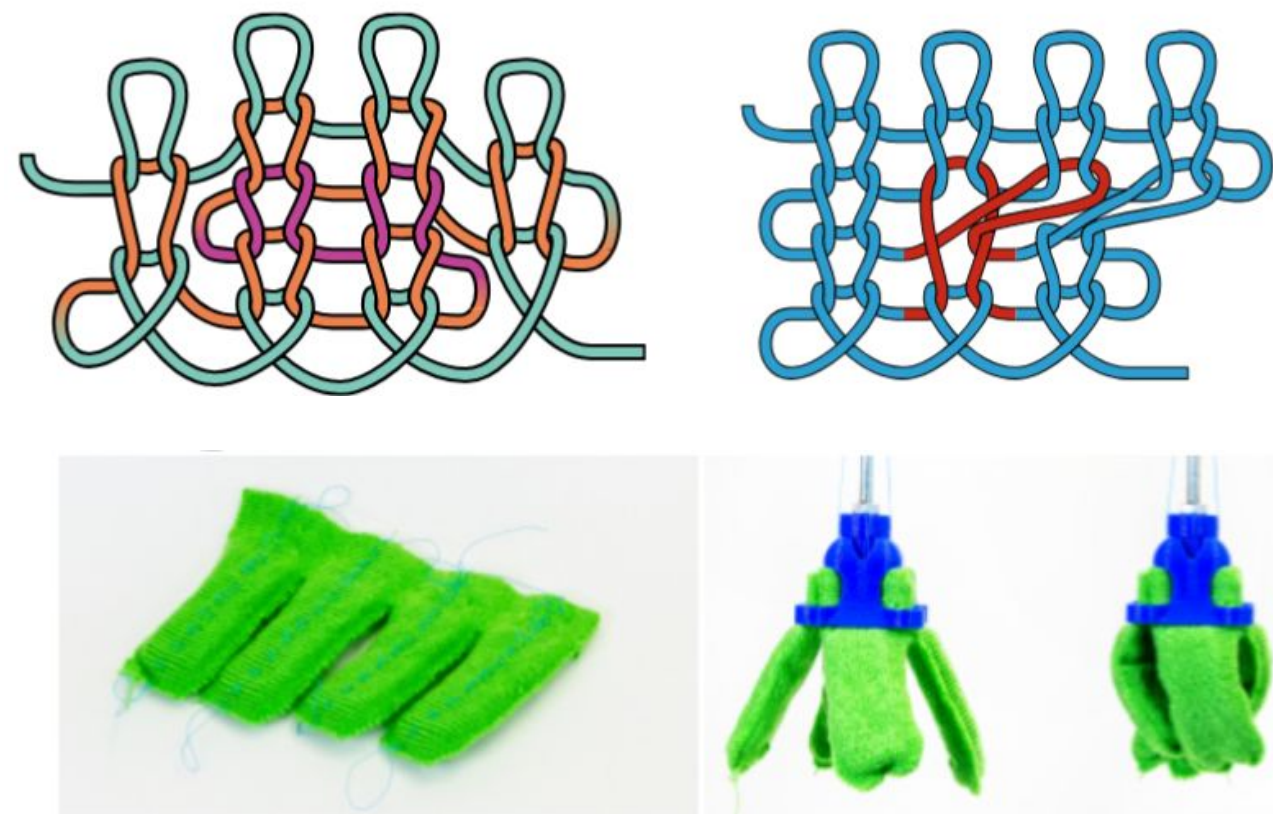
Industrial knitting machines can make complex shapes but are hard to program, and high-level tools remain unused due to inefficient pattern output.
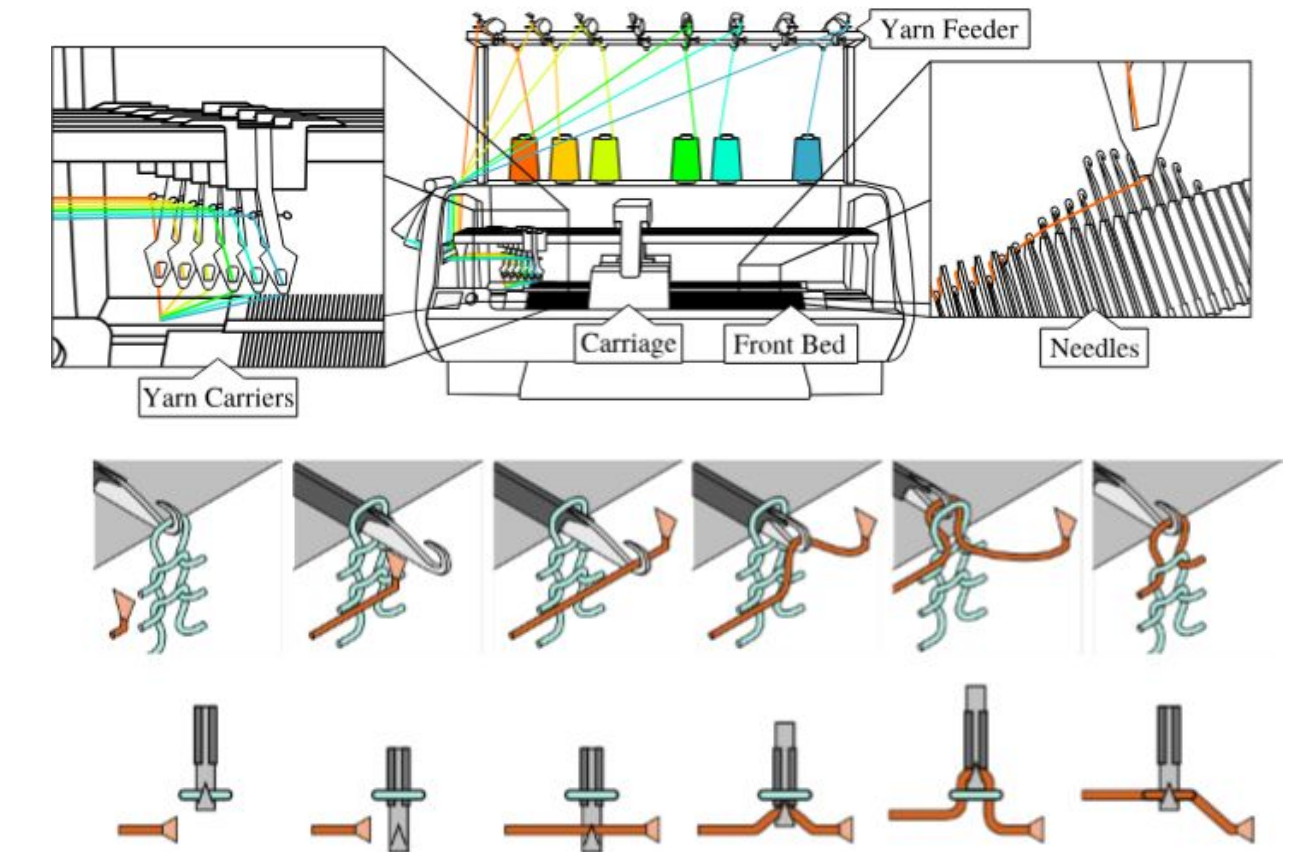
Challenges:

- Software stacks for machine knitting are very rudimentary, holding back better tool development.

(a) Separated Sheets   (b) Stacked Sheets   (c) Linked Sheets
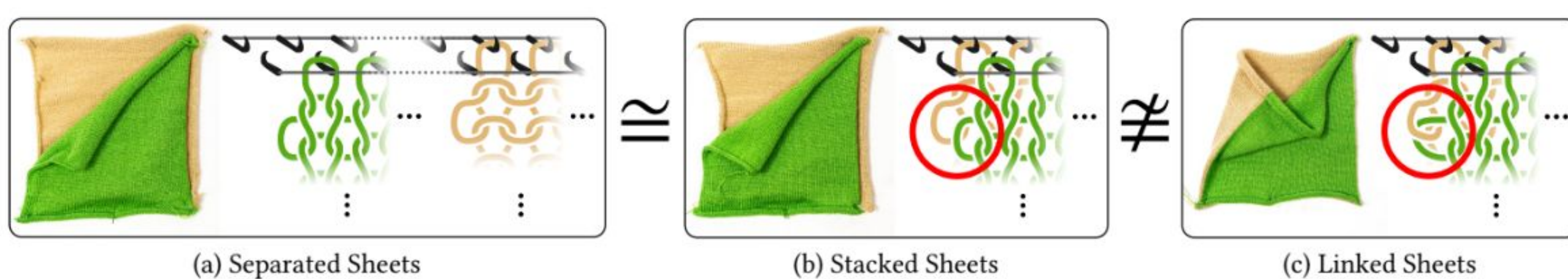
- Knitting programs denote objects, not functions; we need an adequate mathematical domain for *non-rigid objects*: e.g. knot theory.
- Can we define and efficiently (polytime) decide equivalence of knitting machine programs?
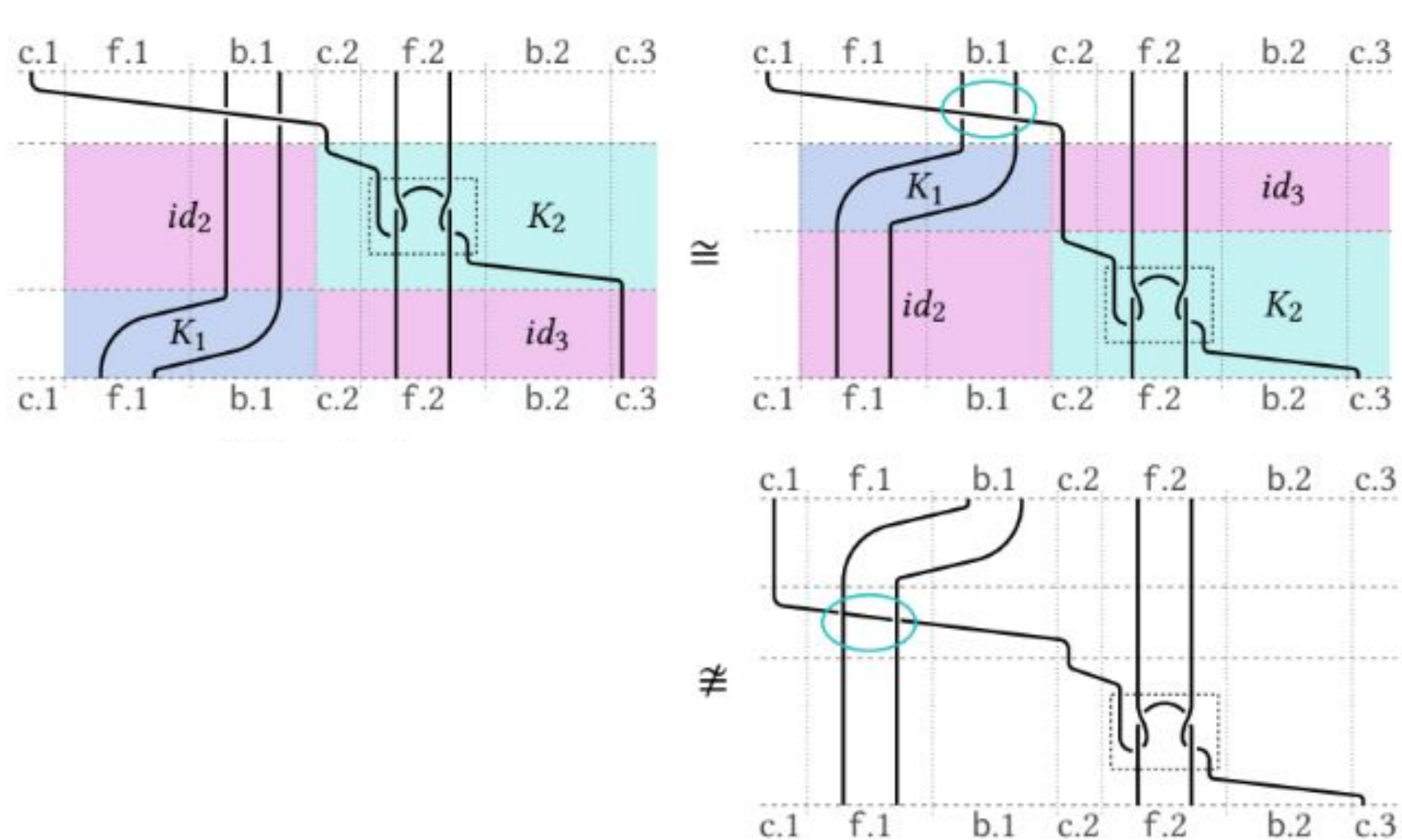
Scientific Impact:

- Extends the scope of programming language theory to analyze the expressivity, safety, equivalence, and performance of manufacturing programs.
- Applies topology and knot theory to define the identity of flexible objects in computation.
- Bridges knitting (via knot theory) with other diagrammatic semantics, e.g. use of string diagrams to describe distributed protocols, as well as quantum and classical circuits.
- Explores knitting optimization as a unique case for user-schedulable language challenges.
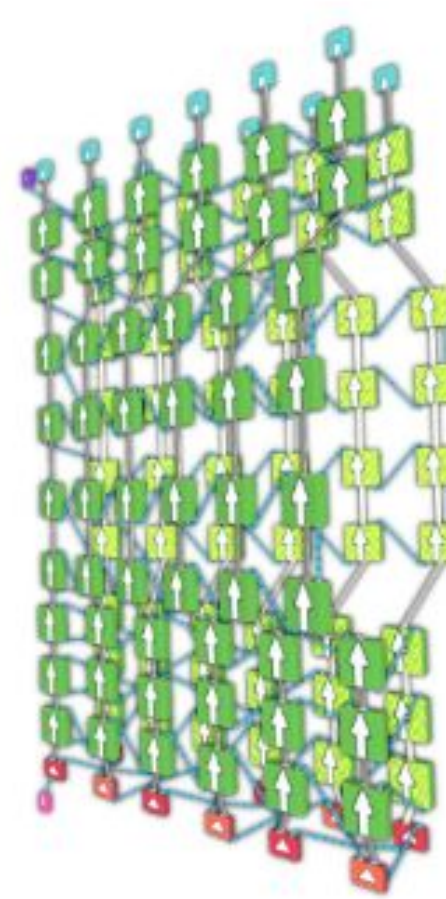
Solutions:

Fenced tangle abstraction for formal semantics for knitting programs

http://semantics.knit.zone; [SIGGRAPH 2023]

Instruction graphs, an IR that captures full range of knitting programs

instruction graph   knit result

http://ufo.knit.zone; [SIGGRAPH ASIA 2024]

Application: *Illusion knitting* enabled by novel scheduling algorithms
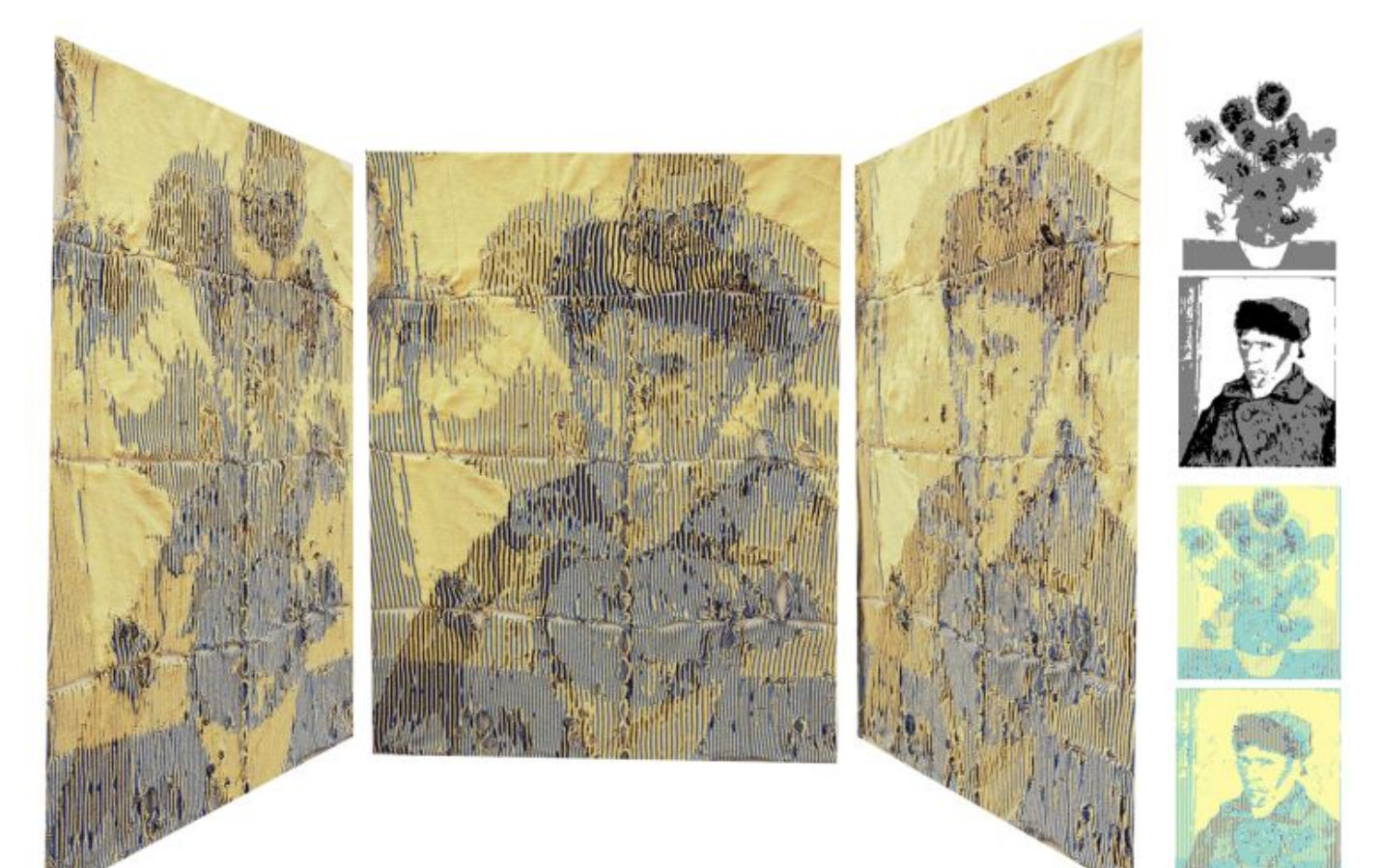
[SIGGRAPH 2024]

Modernizing Knitting Manufacturing

- semantics and IR form a foundation for next-generation knitting design systems
- machine knitting is a low-waste production technique suitable for on-demand and custom manufacturing

Community Building

SIGGRAPH 2024 – Birds of a Feather session on Textiles Research in Computer Graphics
- 100 attendees

Broadening Participation

Knitting as a gateway to programming languages ideas.

- formal semantics connects knitting hobbyists and industrial machine fabrication
- creating a knitout (knitting language) backend for handflat (home/design studio) machines