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THESIS ORAL

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Foundations for 3D Machine Knitting

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Industrial knitting machines are programmable systems that can fabricate complex soft objects. However, this traditional manufacturing system has largely been overlooked as a technology for custom and rapid fabrication. For machine knitting to be widely adopted for custom fabrication, end-users must be allowed to work in an intuitive design space instead of thinking about operations that the hardware executes; with computational tools that bridge the gap between the two.

In this thesis, I lay out foundational tools for machine knitting that allow users to think about "what" they want to create in terms of 3D shapes instead of "how" the machine constructs it. I show that programming for machine knitting can be organized to decouple high-level design challenges from low-level machine input decisions.

Such an organization allows exploration of various aspects of machine-knitting independently: pattern design, layout planning, and machine-code generation. I classify the space of shapes that can be constructed with industrial knitting machines. I present a new data-structure to represent 3D shapes as knitting programs. I describe geometric algorithms to create patterns from 3D models and an editing framework to modify patterns in 3D. For fabrication, I describe a scheduling algorithm to translate patterns into low-level machine code. Together, these tools and techniques allow designers and end-users to treat 3D machine knitting as an accessible 3D-printing-like soft-fabrication system.

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