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One-Dimensional Force Feedback Slider: Digital Platform

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Overview

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- Mixed Reality and FFS
- State-of-the-art UIs for Music

- Analogue Design: Two Applications

- Digital Design: Main Board and Slider Board
- Haptic Profiles
- Applications
- Work in Progress
- Summary and Qustions

Mixed Reality and FFS

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- ForceFeedbackSlider (FFS) is intended to bring real and virtual environments closer; bridging left and right parts of the Milgram continuum

State-of-the-art UIs for Music

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- USB/MIDI state-of-the-art user interfaces for music editing like the Behringer B-Control Fader BCF2000 and the Mackie Control already offer touch-sensitive motorized sliders

POSITION \ FORCE	OUT	IN
OUT	Behringer Mackie FFS	FFS
IN	Behringer Mackie FFS	FFS

- However, the driving force in such sliders cannot be controlled since they are based on speed control ...

State-of-the-art UIs for Music

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- ... and their control employs a constant current, giving a constant torque. While such control is sufficient for audio editing, we aim for a more generic interface where force serves as feedback in user-system interaction.

POSITION \ FORCE	OUT	IN
OUT	Behringer Mackie FFS	FFS
IN	Behringer Mackie FFS	FFS

- The novelty of the FFS lies in its capacity to control the driving force while at the same time measuring the force applied by the user

Analogue Design: Two Applications

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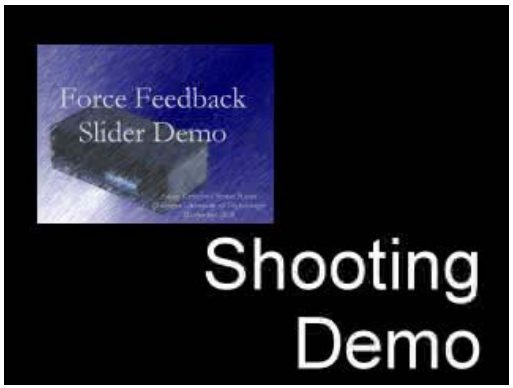
Catapult



with
Adjan Kretz & Remo Huber

FeelTheBeat

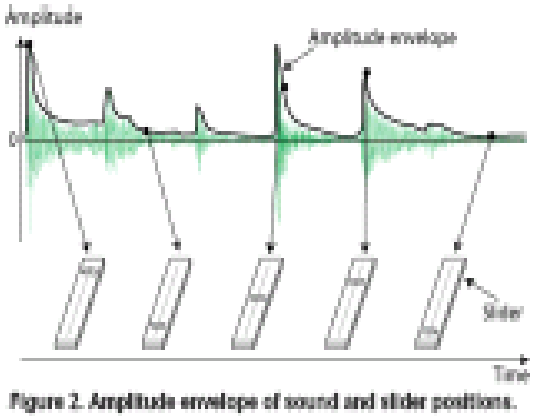


Figure 2. Amplitude envelope of sound and slider positions.

with
Tue Haste Andersen

Use Requirements for Digital Design

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Based on experience with analog FFS, we formulated *use requirements* for digital FFS

- low latency
- high stability
- easy access to update motor control function
- platform independency
- extendibility to a maximum of 16 sliders mounted into a compact box
- programmable via a standardized API
- remote haptic collaboration enabled

Digital Design: Main Board

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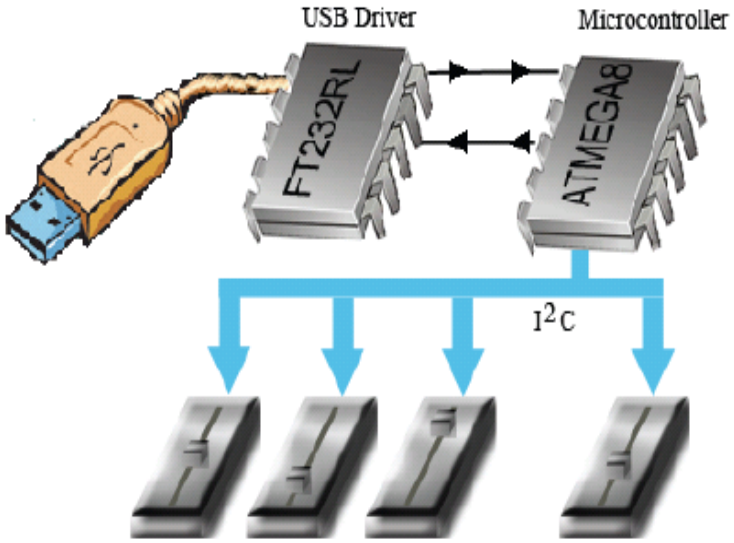
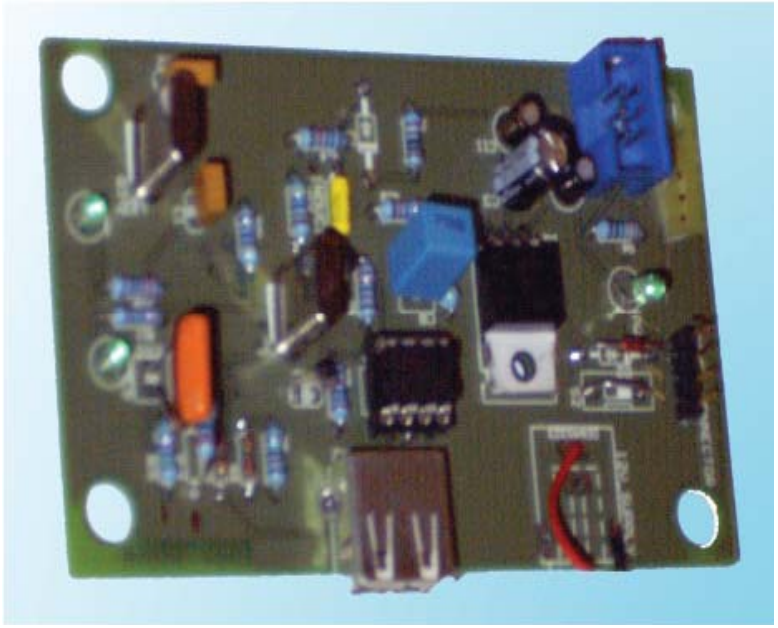
- Sliders operate independently and the bus is used to read the force or position of each slider and to send Look-Up Tables (LUT) to the microcontroller in the slider board.





Digital Design: Main Board

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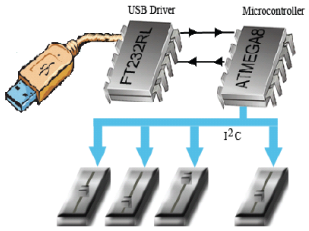
- One microcontroller commands the mainboard and each slider board is then commanded by its own microcontroller
- We use the Atmega-8 microcontroller with a 16 MHz crystal. The RISC architecture of this chip can reach up to 16 MIPS
- Fast enough to control the system since motor runs at up to 20 KHz



Digital Design: Slider Board

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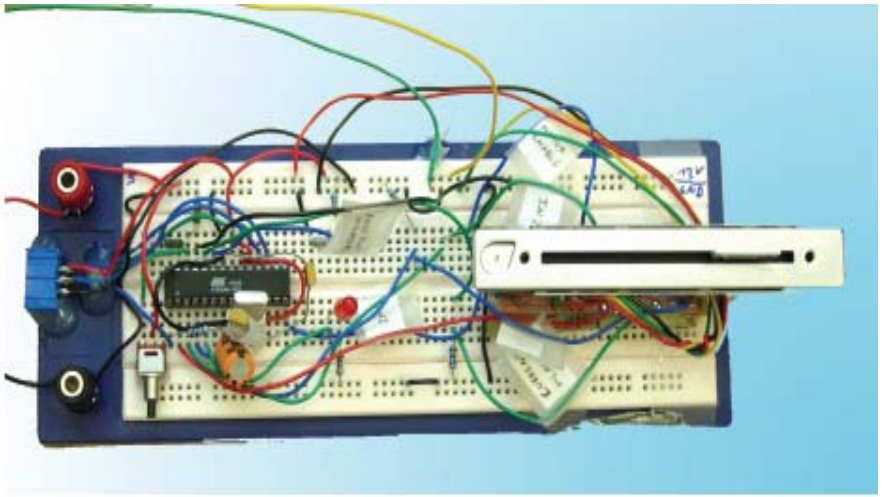

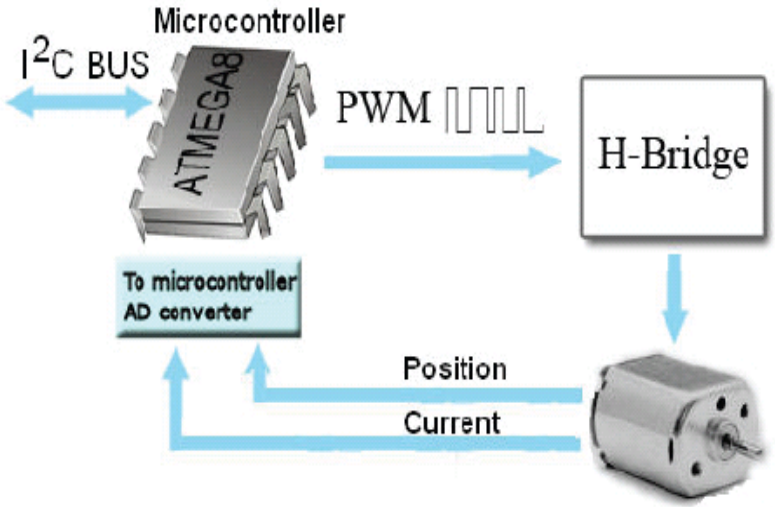

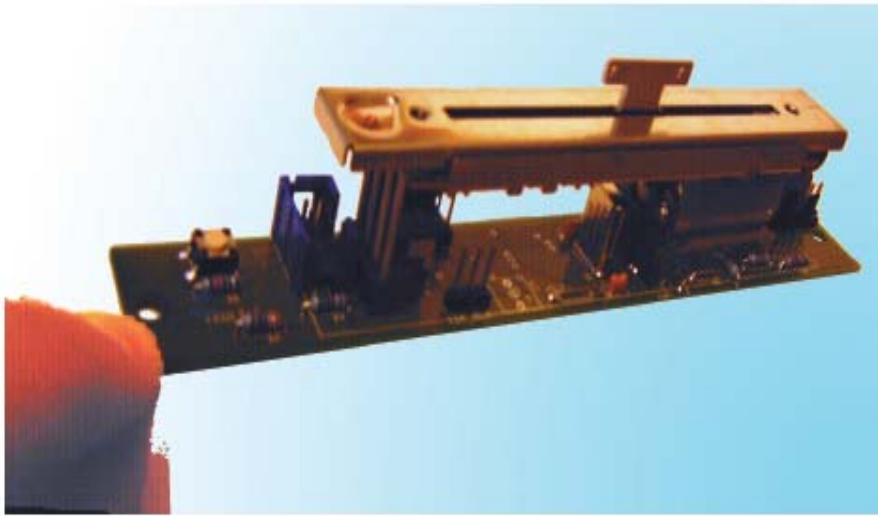

Digital Design: Slider Board

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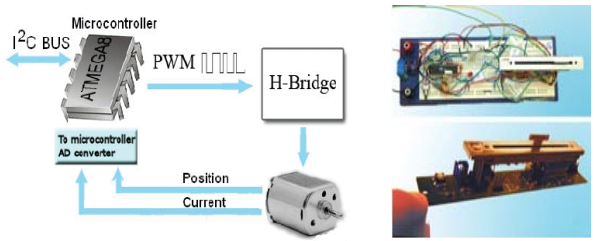
- The control of the motor is achieved using PWM signals (Pulse Width Modulation) to control the voltage supplied and with it, the torque (which is proportional to the current). This PWM can be done in different ways. We used a fixed frequency of 10 kHz, generated with the microcontroller timer with a variable on/off cycle.



Programming Haptic Profiles

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The slider platform is designed to memorize LUTs of 256 bytes for position and 256 bytes for force. With these LUTs, the slider is able to perform these different functions, or any combinations of these:

- *Position*
- *Elasticity*
- *Detents*
- *Texture*
- *Oscillation*

Application: Remote Collaboration

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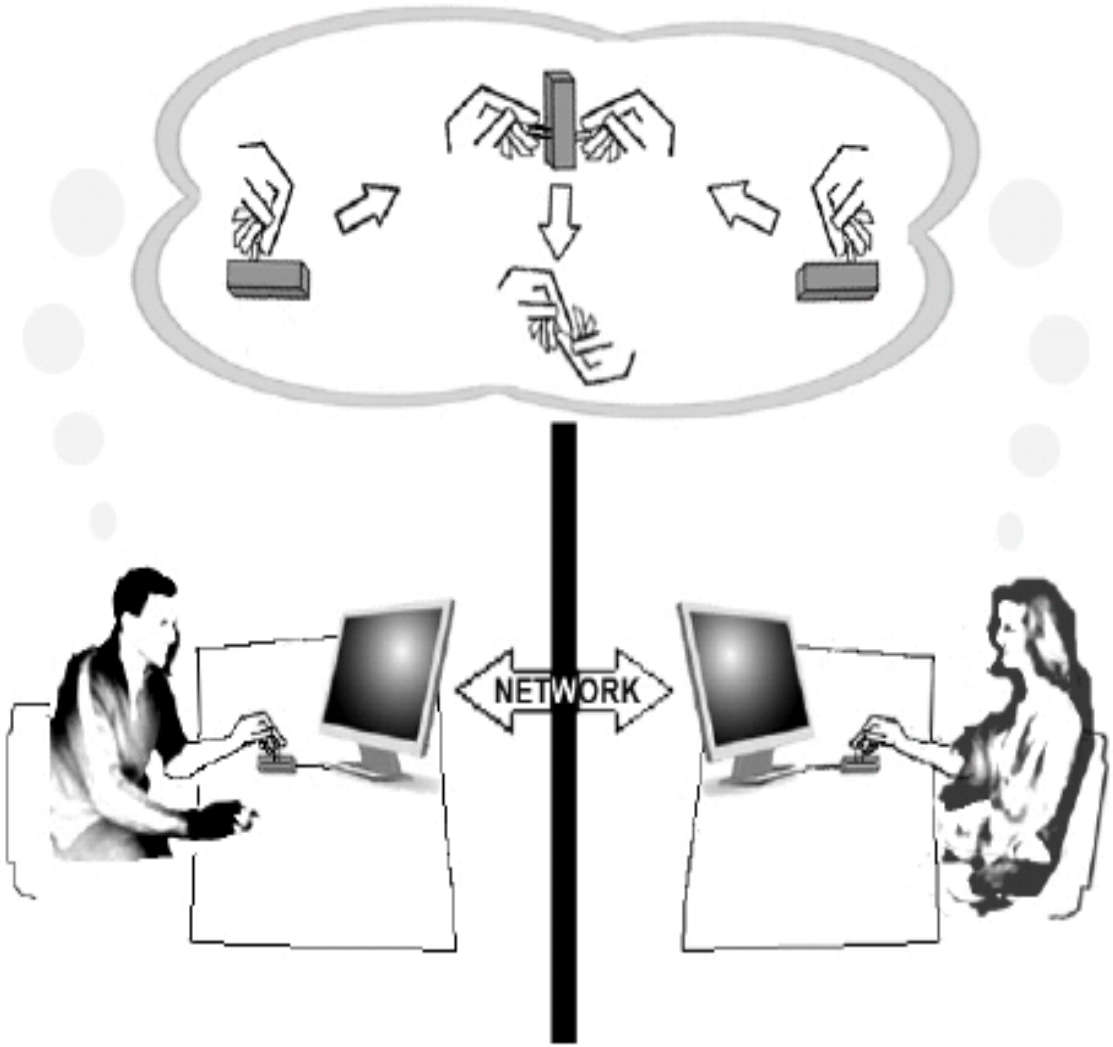

Application: Economic Modelling

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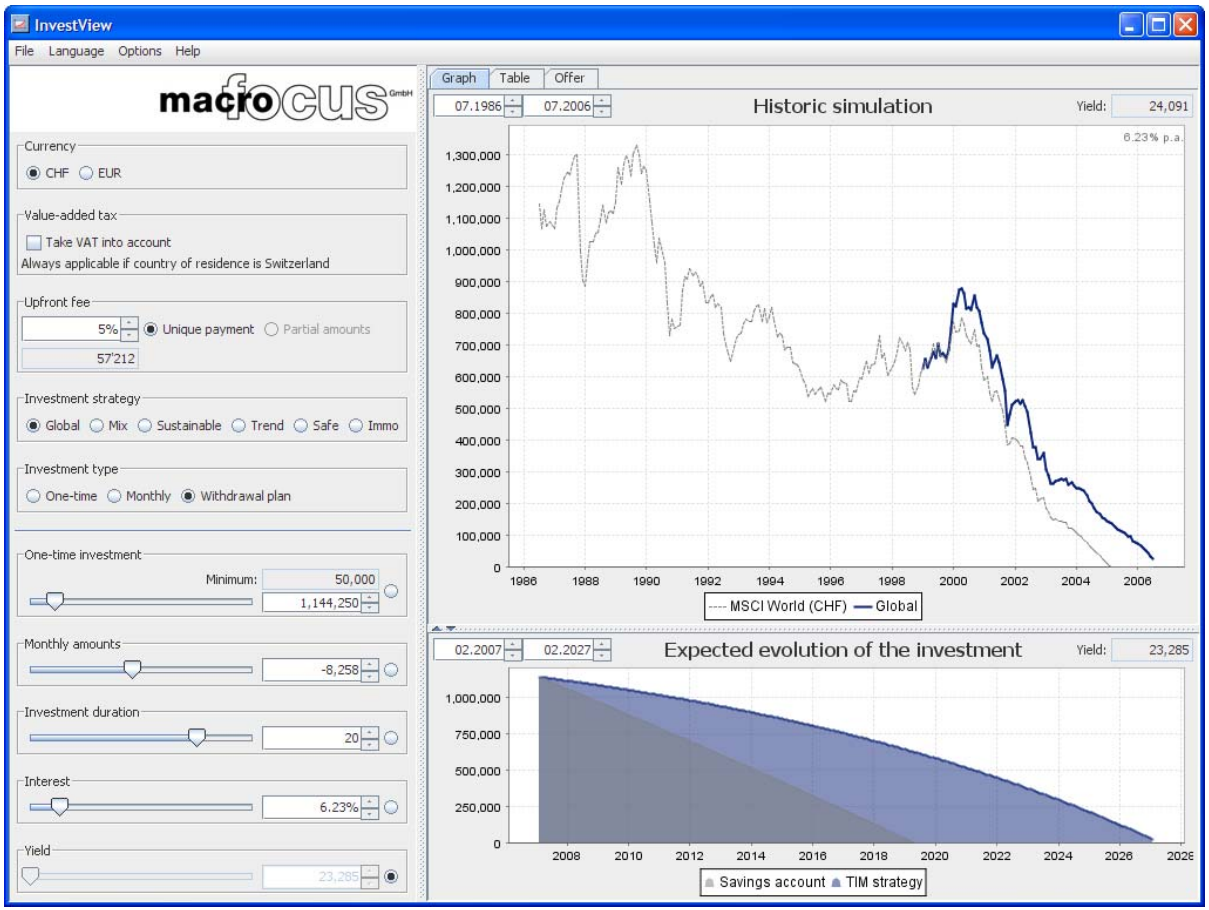

GUI demo: http://www.timvest.ch/content.php?underchapter=invest_view

Potential Application

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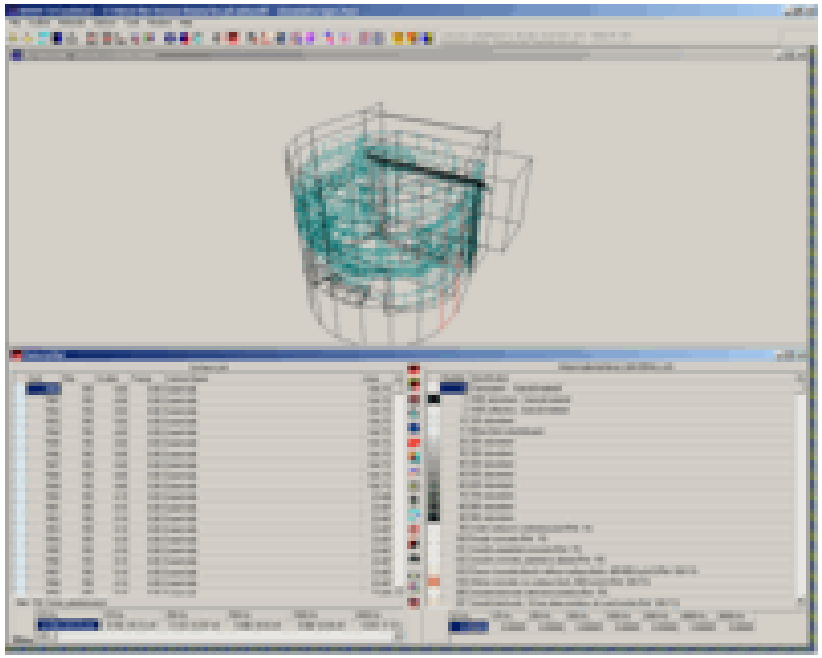
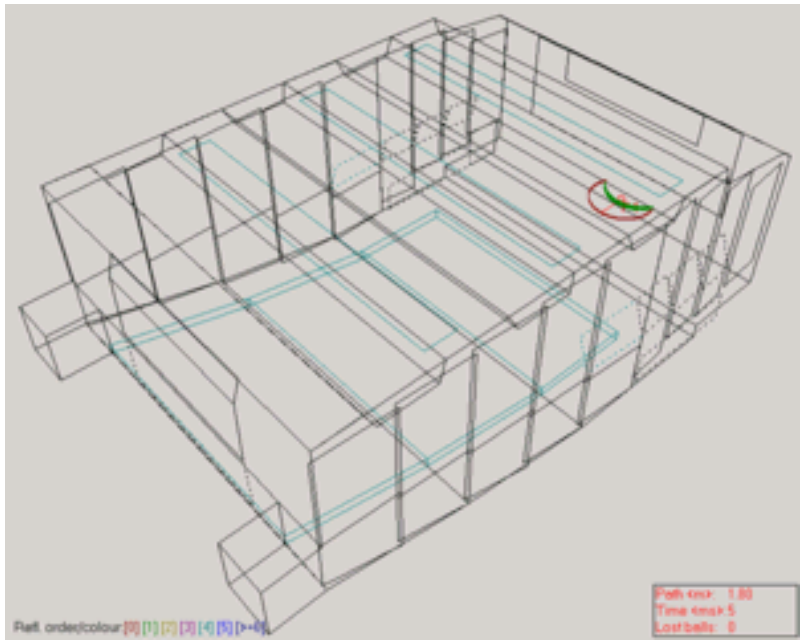
- Multifactor acoustics model for 3D space





Work In Progress: Slider Box

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Work In Progress: PID Control

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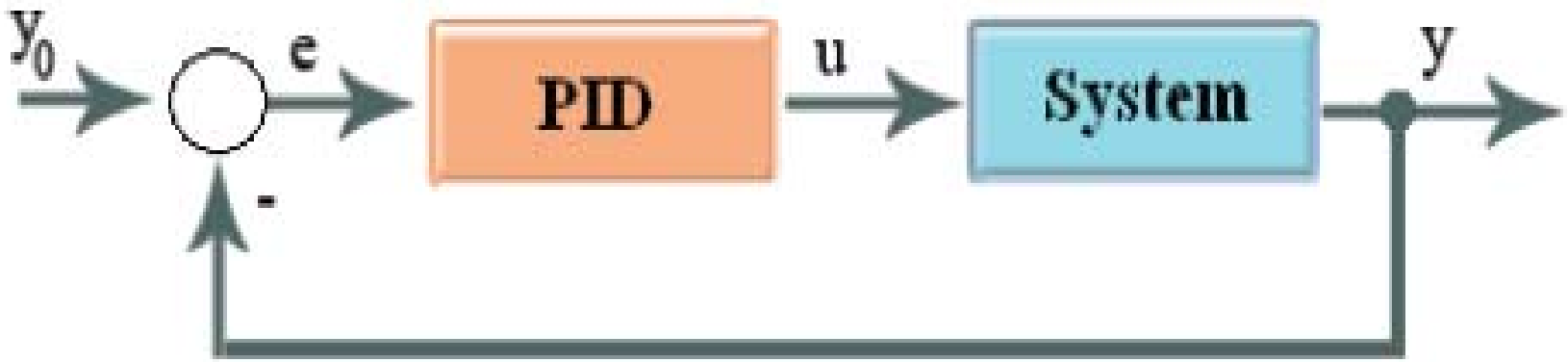
- Close Loop System with PID where y_0 is reference input, e is error, u is controller output, and y is desired system output



Summary and Outlook

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- User studies with realized prototypes
- Search killer applications

- Project web site, including video material: http://t2i.se/projects/ff.php