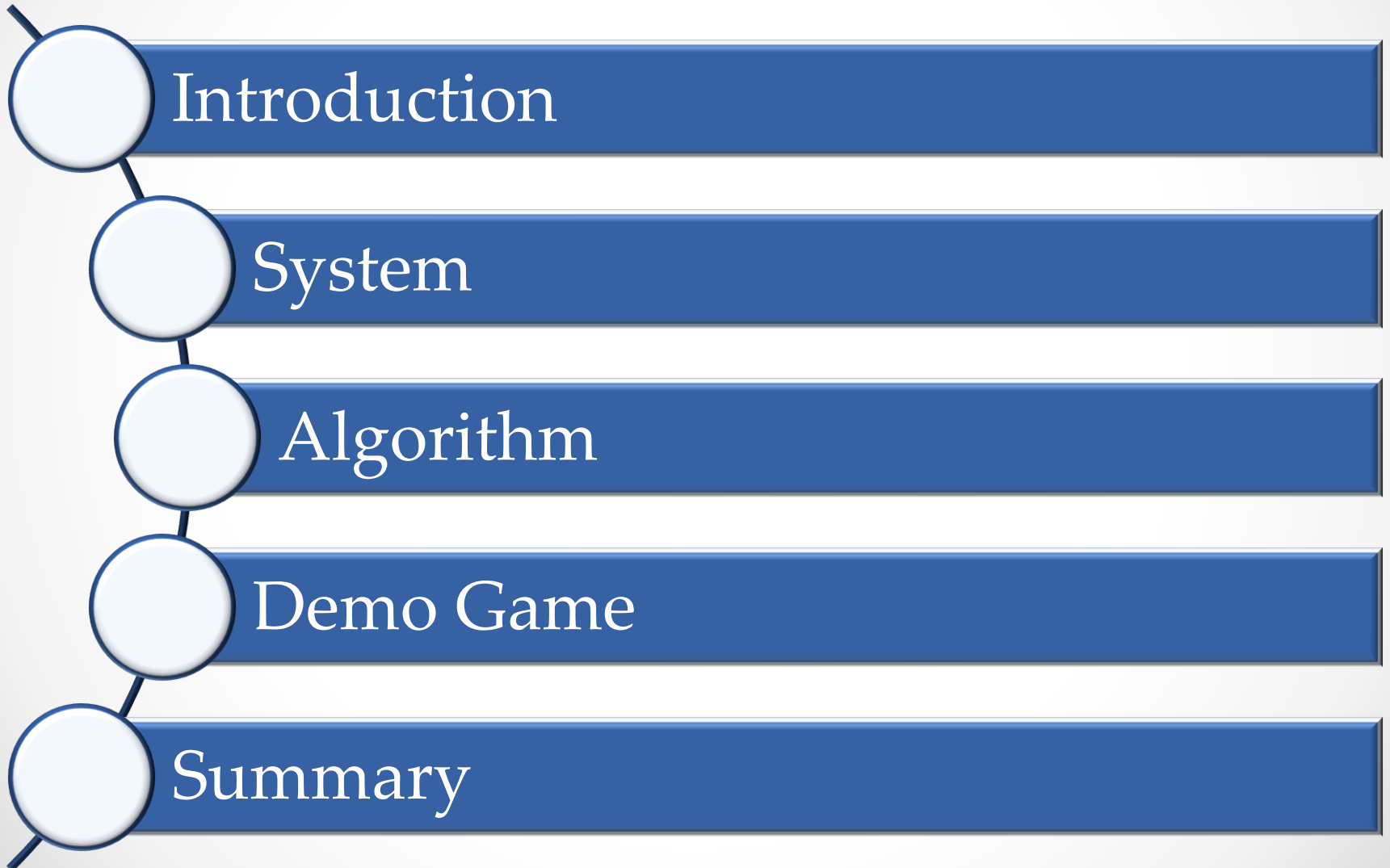# Shape Recognition for Multi-Touch Table

SIPL Day

10/06/2012

Students: Itay Hubara

              Amit Nishry

Supervisor: Yair Moshe

Outline

Introduction

System

Algorithm

Demo Game

Summary

Background

- Multi-touch is starting to appear in every day computers
- New User Interfaces (NUI) are extensively pursued

Motivation

- Existing multi-touch surfaces are expensive

- Current technology is unable to recognize shapes

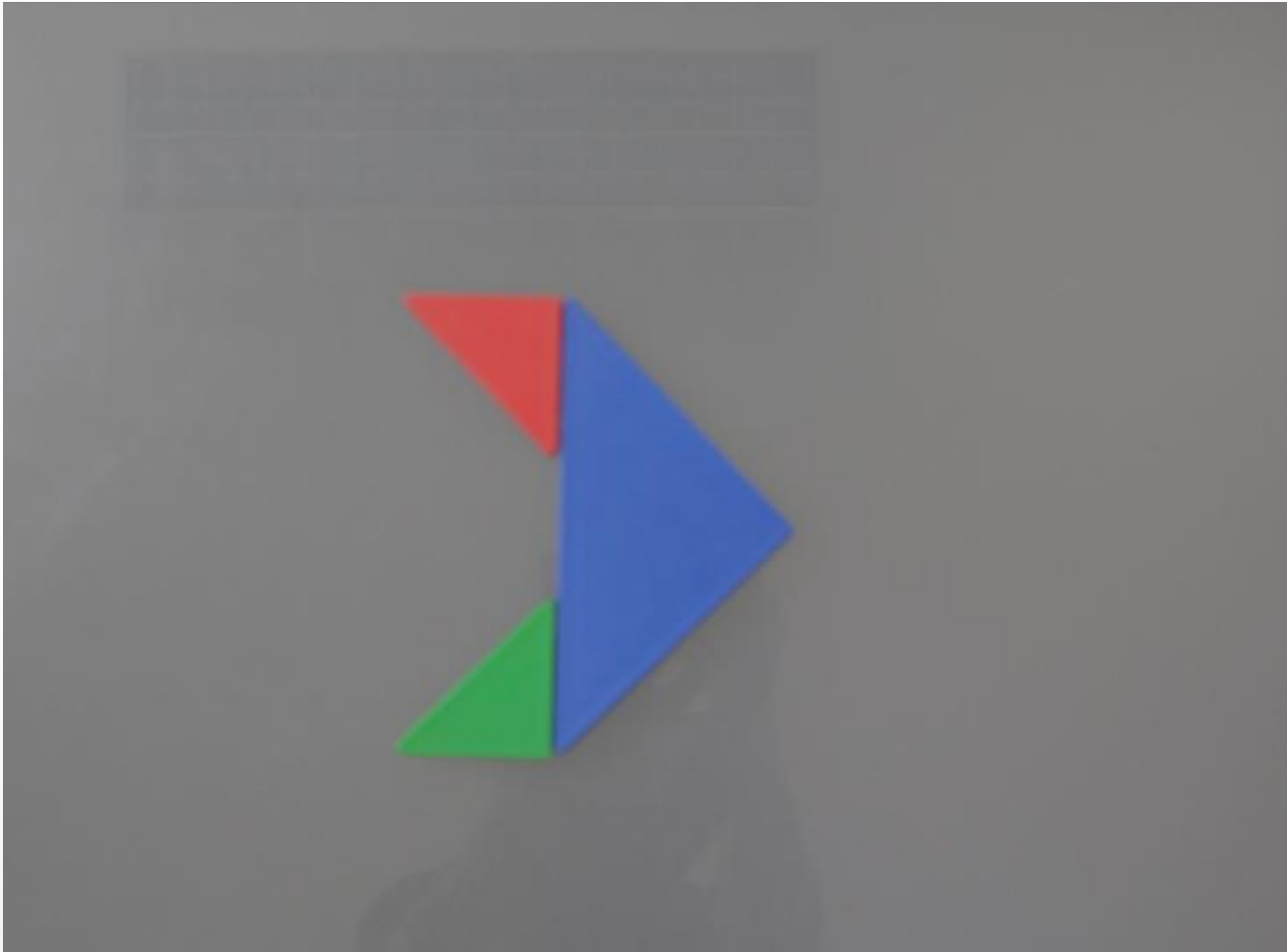- Shape recognition enhances user interface

Challenges

- Noisy input image

- Real-time constrains

- Implementing into open-source environment

- Creating a complete system solution
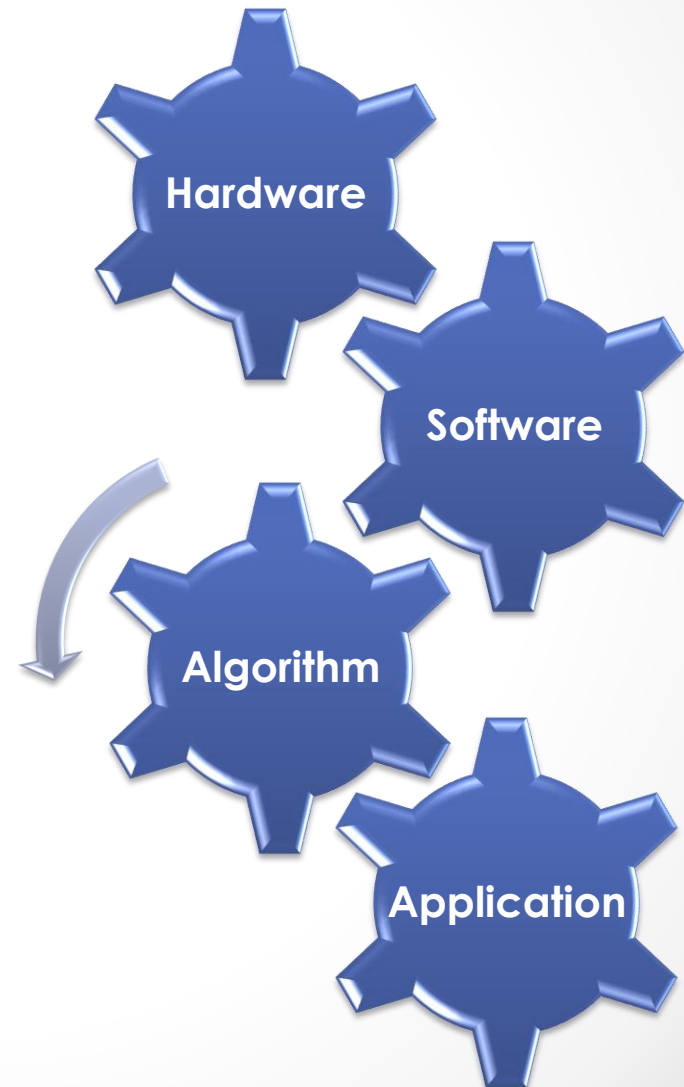
- Shape combinations and movement
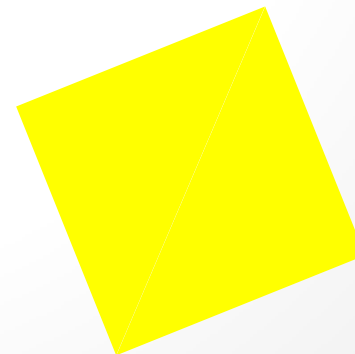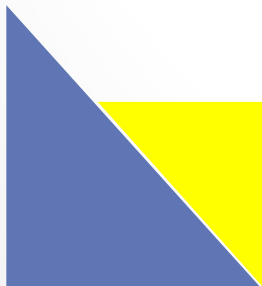
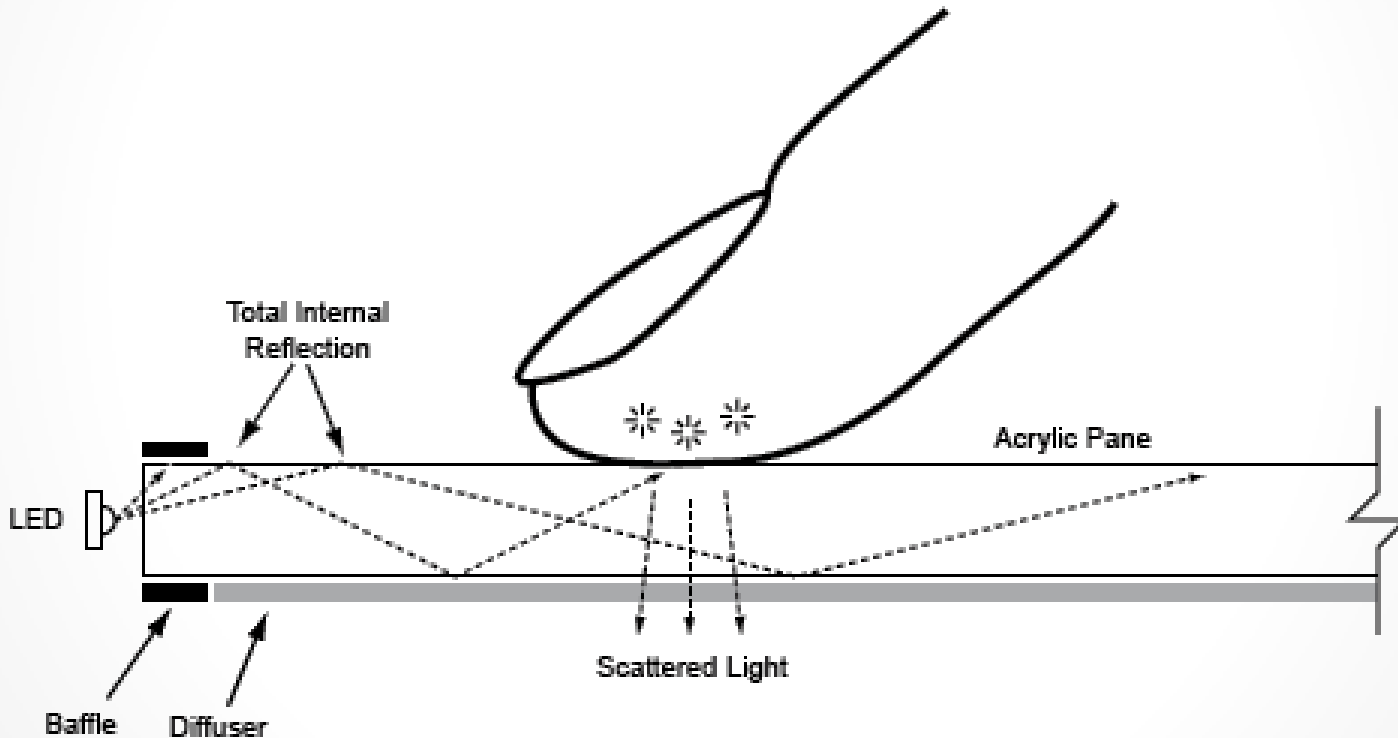# Challenges (cont.)

- Real-world view

System

- Hardware
  - Multi-Touch Table
  - FTIR Technology
- Software
  - Community Core Vision
  - Client / Server Model
- Algorithm
  - Image Processing
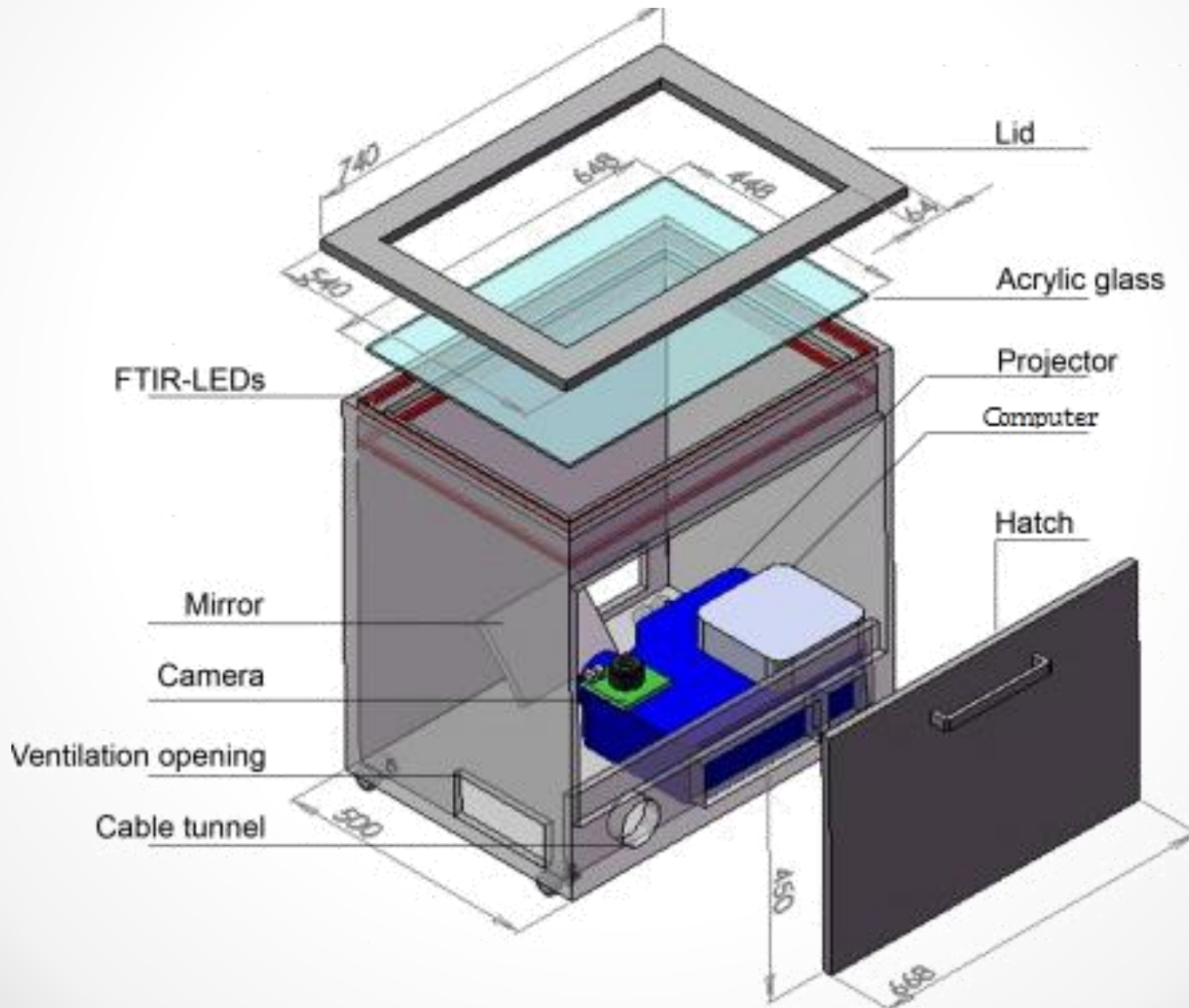 - Shape Detection
  - Tracking
- Application
  - Game

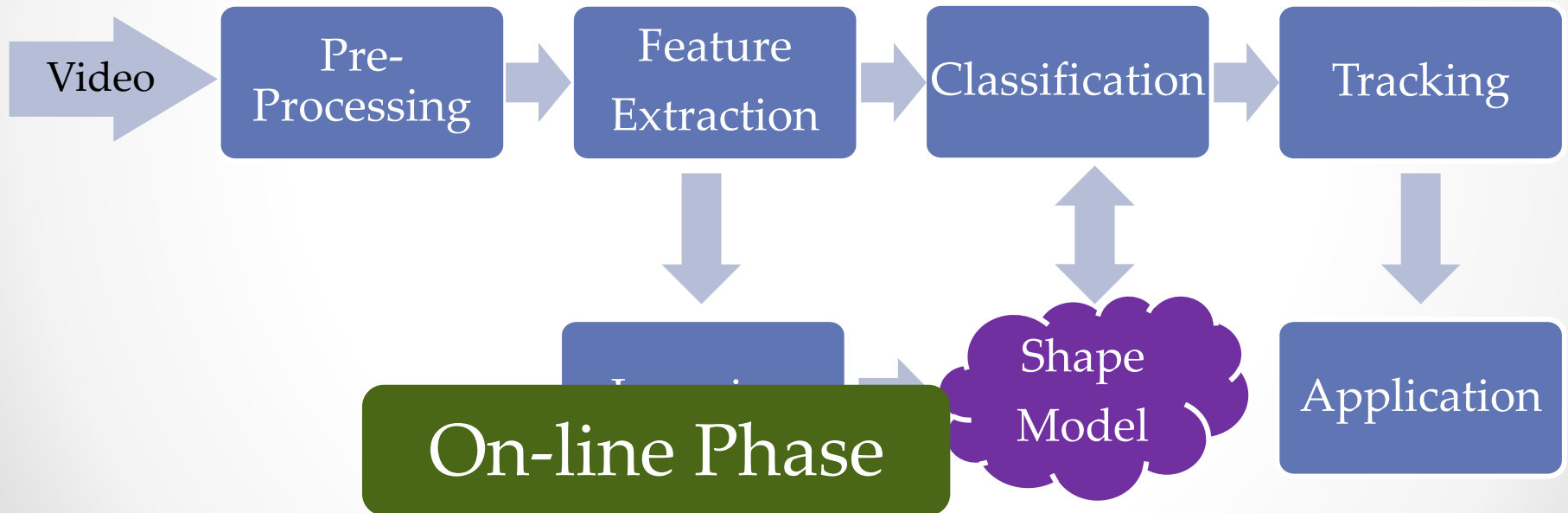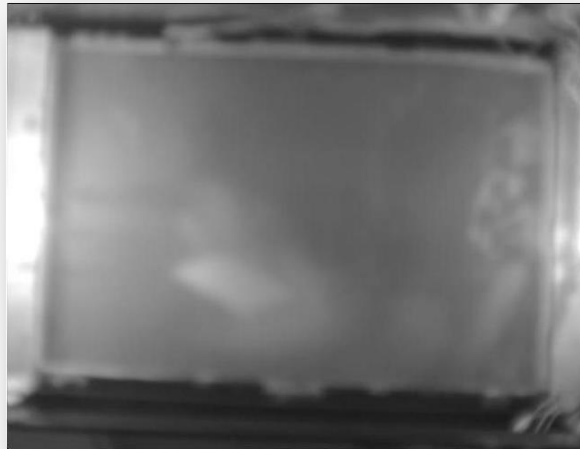FTIR - Frustrated Total Internal Reflection

Frustrated Total Internal Reflection

Multi-Touch Table

Shape Recognition

Learning Phase

Video → Pre-Processing → Feature Extraction → Classification → Tracking

On-line Phase

Shape Model

Application
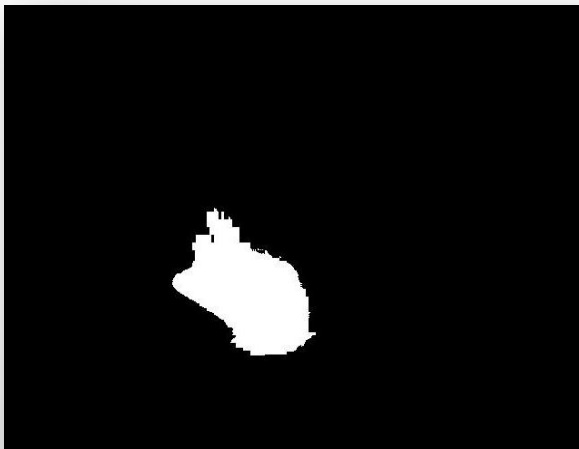
Pre-Processing

IR input
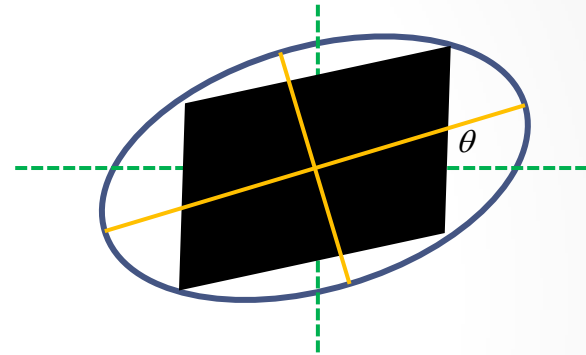

Background removed

Global threshold

Adaptive threshold

11

Selected Features

- Chosen features:
  - Area
  - Major & minor axis
  - Eccentricity
  - 4 Hu moments: $\varphi_1,\ \varphi_4,\ \varphi_6,\ \varphi_7$

- Empirical selection based on cross validation

[Hu, 1962]
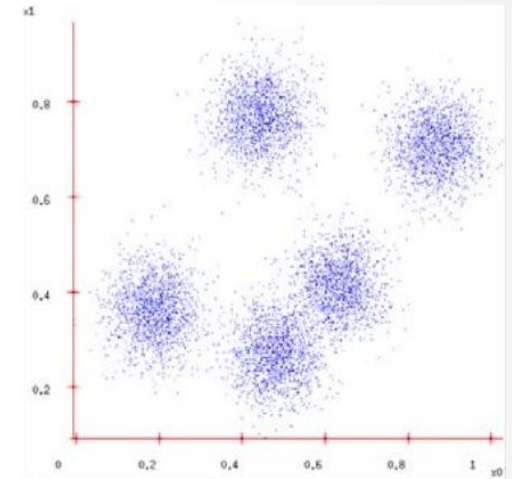[Sarfraz, 1993]

12

Image Moments

- Complex moments:

$$c_{pq} = \int\limits_{-\infty}^{\infty} \int\limits_{-\infty}^{\infty} \left(x+iy\right)^p \left(x-iy\right)^q \chi\left(x,y\right) dxdy$$

$\chi(x,y)$ - image indicator function

- Centralized moments $\rightarrow$ translation invariance

- Chosen moments are rotation invariant

13

Learning & Classification

- Independent Gaussian distributions

- Naïve Bayes Classifier

- For each shape s_j and feature f_i assume: $p(f_i \mid s_j) \sim N\left(\mu_i, \sigma_i^2\right)$

$$p(s_j \mid f_1, \ldots, f_m) \propto p(s_j) \cdot \prod_{i=1}^{m} p(f_i \mid s_j)$$

$$\hat{s} = \text{classify}(f_1, \ldots, f_m) = \underset{s_j}{\text{argmax}} \; p(s_j \mid f_1, \ldots, f_m)$$

14

Naïve Bayes Classifier

- Advantages:
  - Generic
  - Fast
  - Allows thresholding
  - Good performance

- Disadvantages:
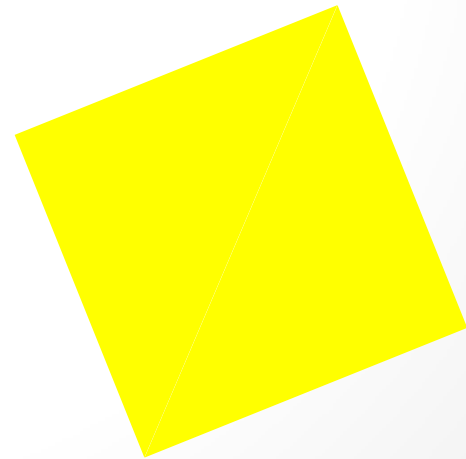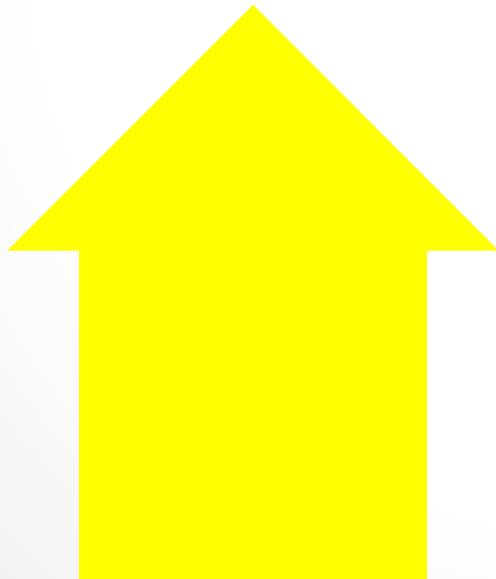 - Long offline learning process

Tracking

- Nearest neighbors tracking

- Simplifies data handling

- Prevents false detections

- Allows complex situations
  - Shape combinations
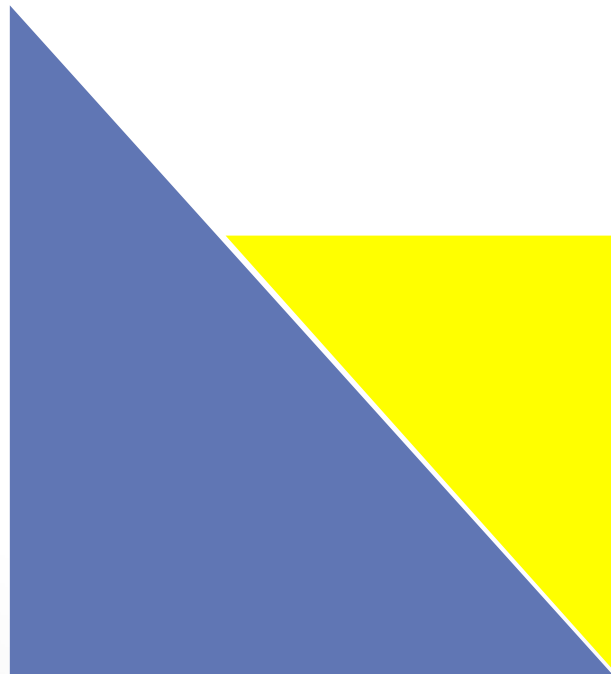 - Internal movement in a combination

Complex Situations

- Shape combinations can appear as one (legitimate) shape
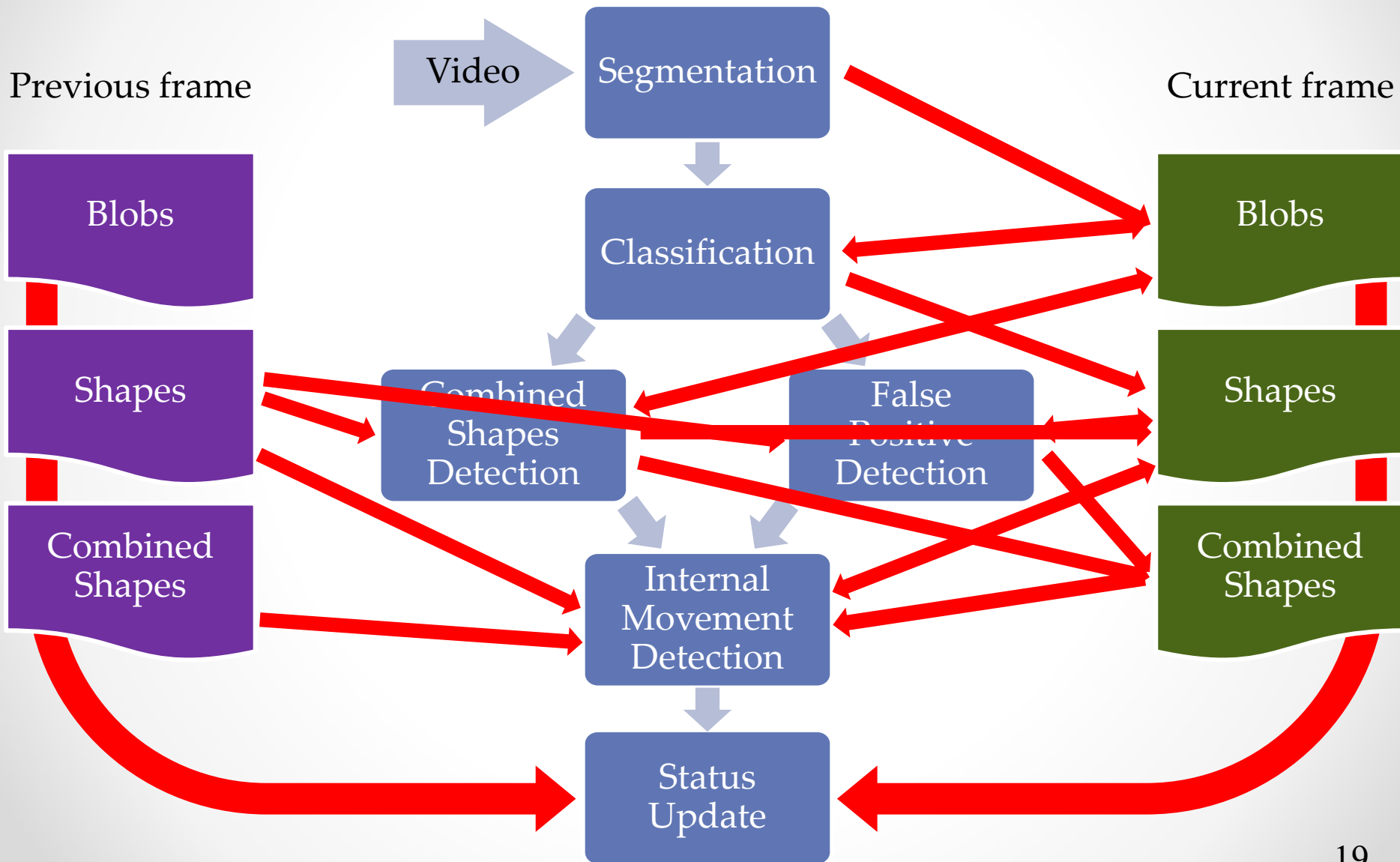
- Possible classification mistakes:

Internal Shape Movement

- Complex shape modification

- Combined shape structure is maintained

Tracking

Previous frame

Current frame

Video

Segmentation

Classification

Blobs

Shapes

Combined Shapes

Blobs

Shapes

Combined Shapes

Combined Shapes Detection

False Positive Detection
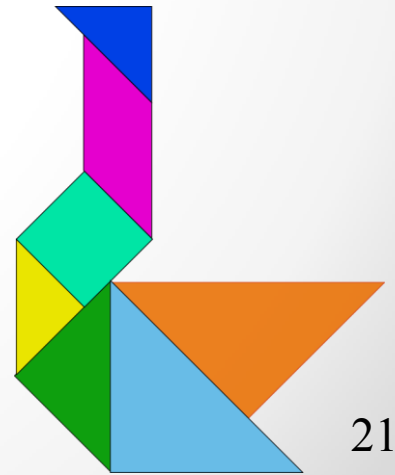
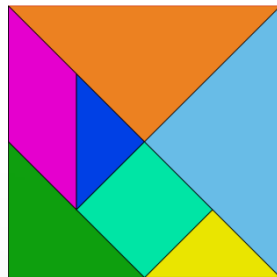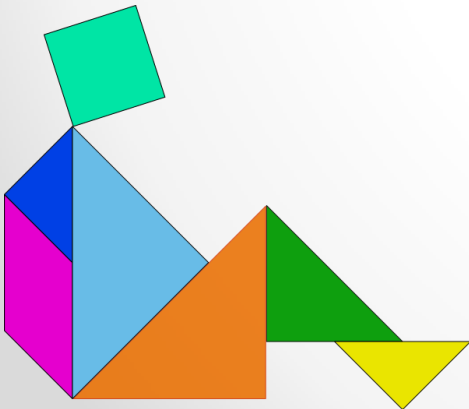Internal Movement Detection

Status Update

19

Application

- Many possible applications

- Client / Server model established

- Community Core Vision (CCV)

- Tangible User Interface Objects (TUIO) protocol for data transfer

Tangram

- Chinese dissection puzzle with seven shapes

- The objective is to fill a given silhouette

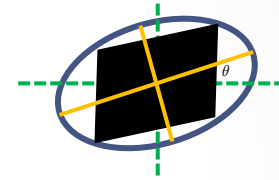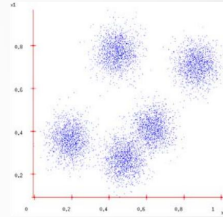- Demonstrates the algorithm capabilities
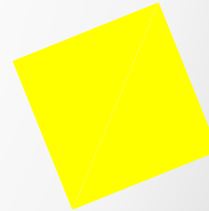
Summary

Multi-Touch table

Feature Extraction

Shape Classification

Tracking

Complex situations

Open-source code

Tangram