# Golf Club Head Tracking

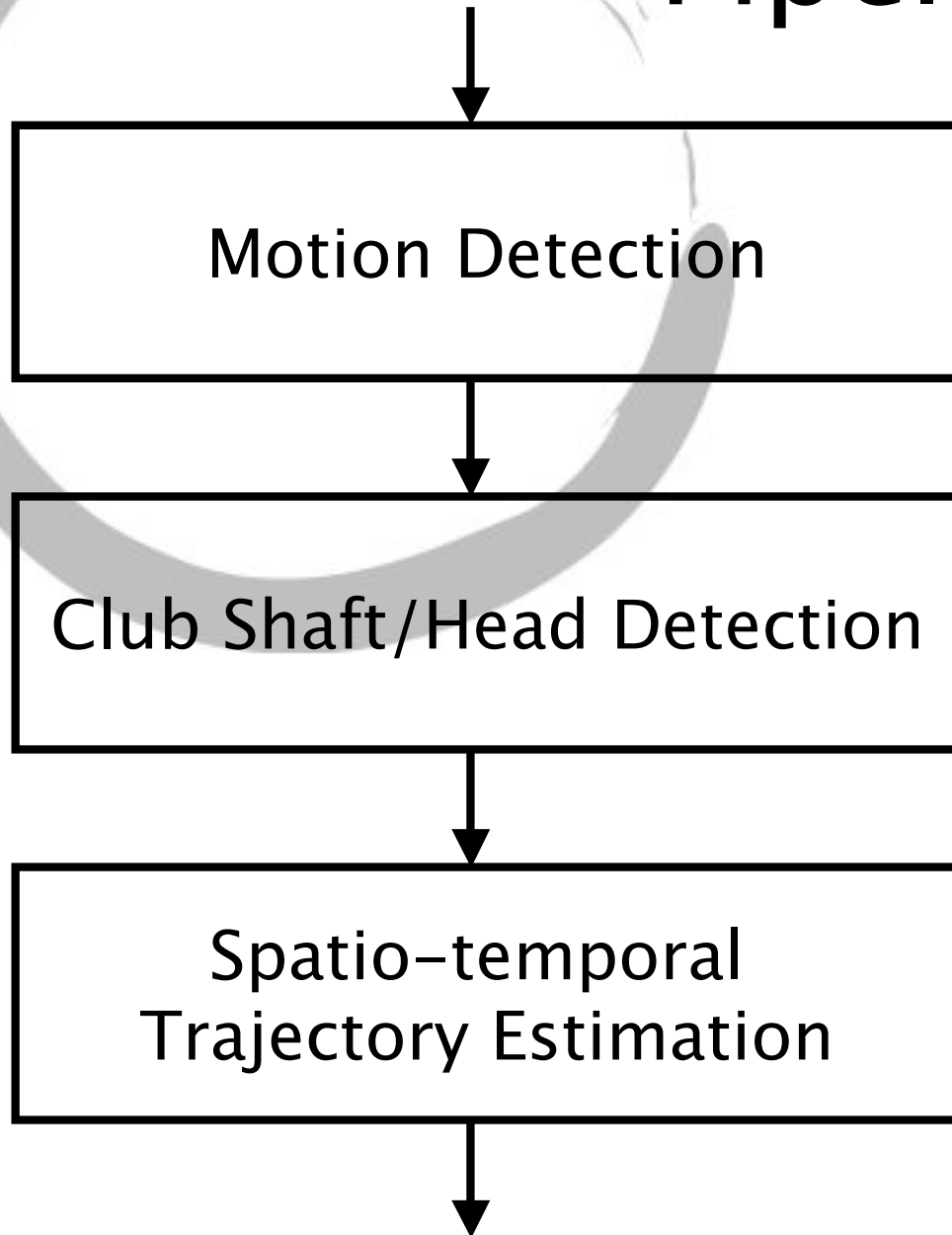## Ravi Chugh
## Krystle de Mesa

# Motivation

- Reconstruct golf swing from video
- To enable applications in swing analysis, instruction, entertainment
- We focus on the club head path

# Assumptions

- High frame rate (synthetically made)
- Fixed camera
- Stationary background

# Pipeline

Motion Detection

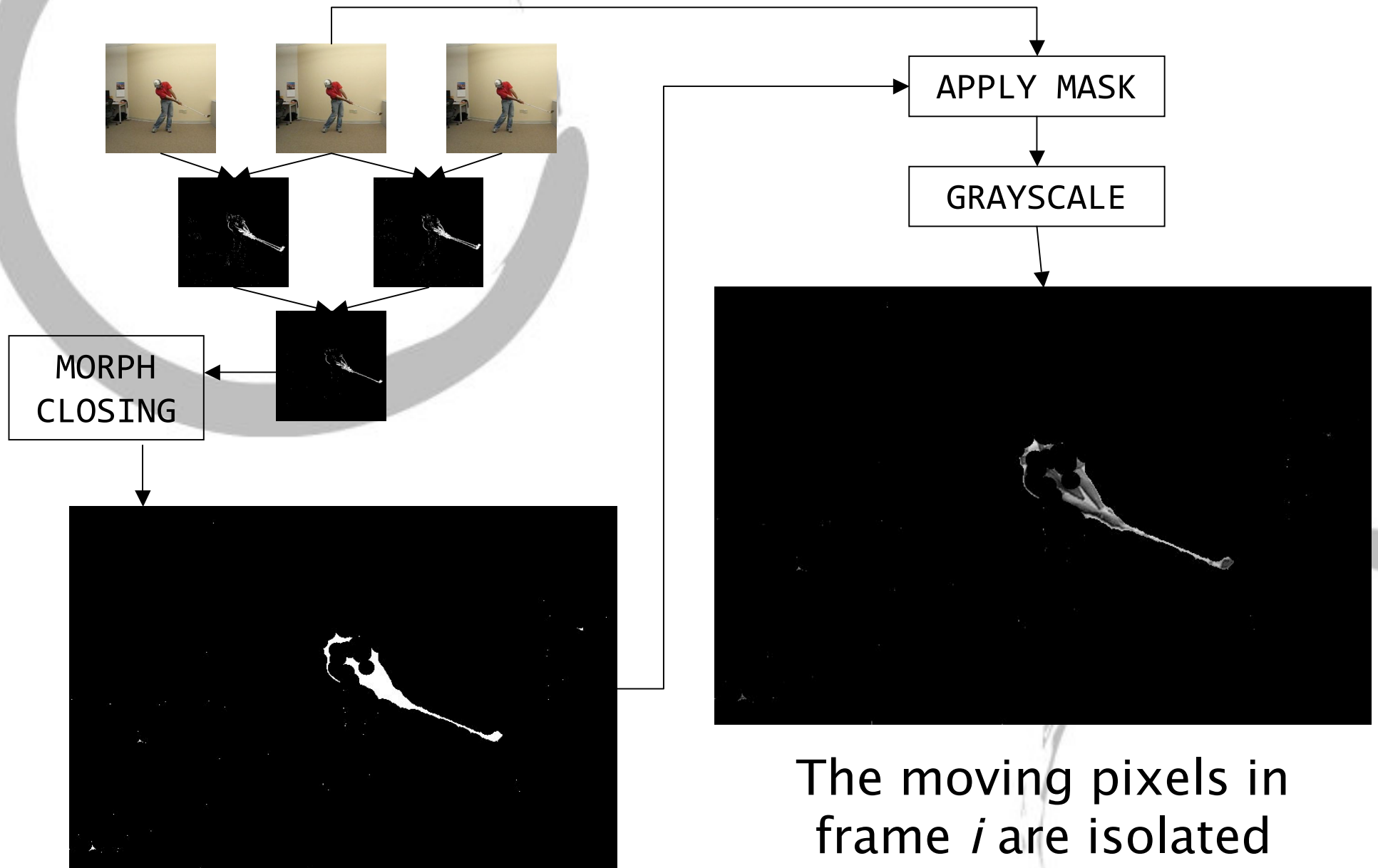Club Shaft/Head Detection

Spatio–temporal Trajectory Estimation

Our approach is based largely on [Gehrig BMVC 03].

We explore some different methods for generating club head hypotheses and estimating trajectory.

# Motion Detection

# Motion Detection



APPLY MASK

GRAYSCALE

MORPH CLOSING

The moving pixels in frame *i* are isolated
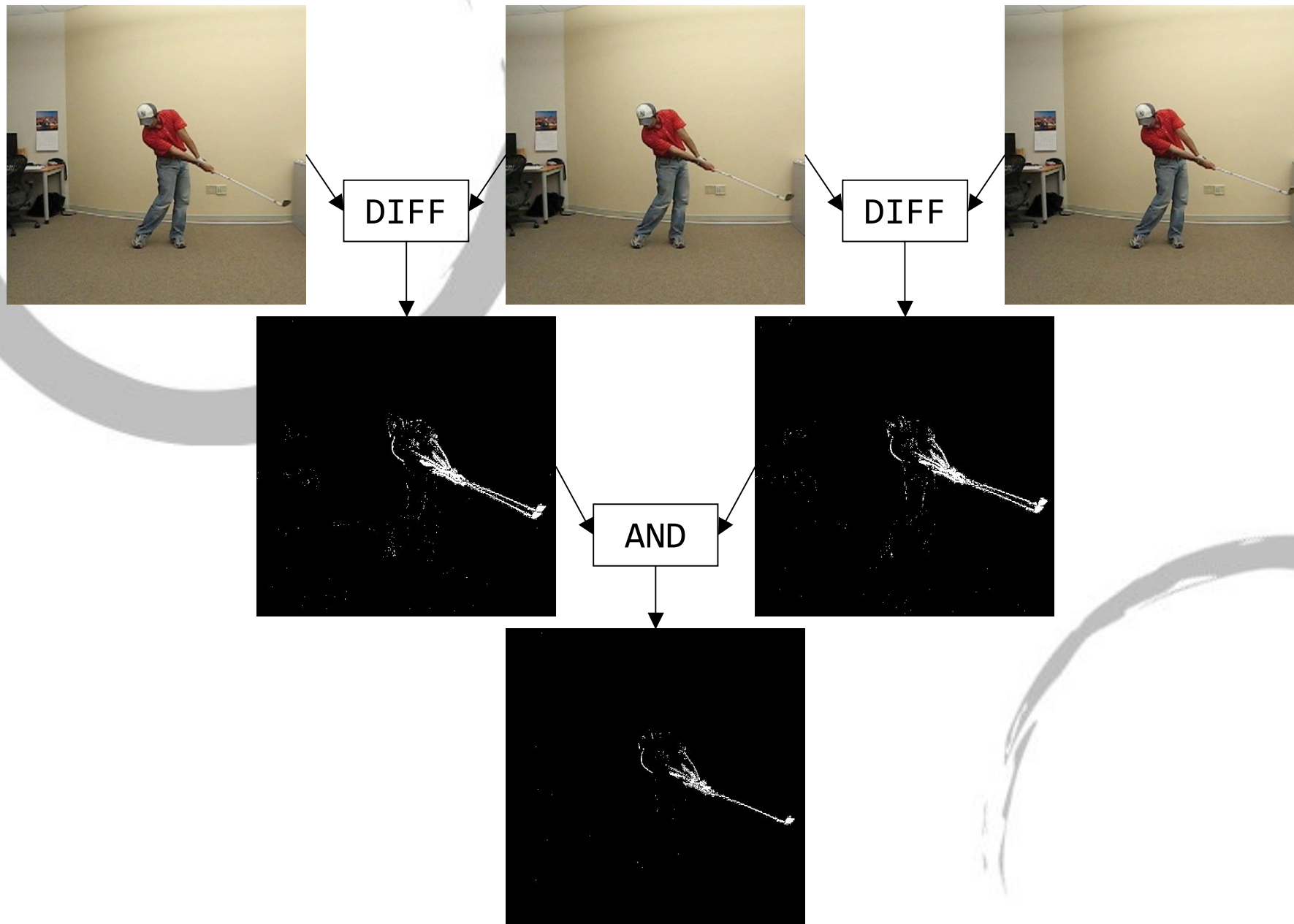
# Segment Detection



CANNY
EDGE

HOUGH TRANSFORM

strict
threshold

loose
threshold

# Segment Detection

- In general, the strict threshold has low accept and false positive rates

- The loose threshold has high rates

- We use both to make a club shaft hypothesis $s_i$ in frame $i$:
  - If 1 GOOD segment, keep it
  - If 2 GOOD segments, merge and keep
  - Else choose the BAD segment that minimizes an error function $f(s_{i-1})$

# Club Head Detection

- For each $s_i$, we need to choose the club head end

- Pick the one farther from a central reference

- Many club head guesses $h_i$ are wrong

- But that's okay!

# Trajectory Estimation

- Consider upswing and downswing separately

- Procedure to identify transition frame is not yet robust

- Instead, ask the user to supply it
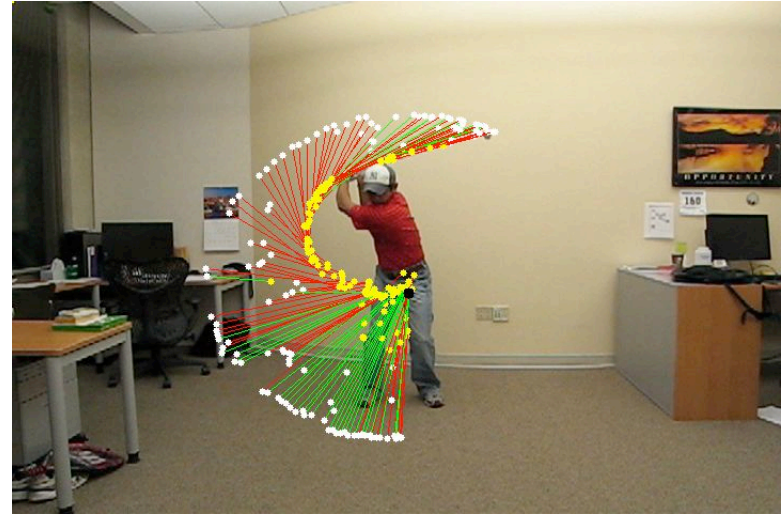
# Downswing Simplification

- Club head hypotheses towards the end of the downswing tend to be inaccurate

- Also, need to offset angles when club passes $2\pi$

- For simplification, we analyze only until $2\pi$

- Again, ask the user for this info

# RANSAC Fitting
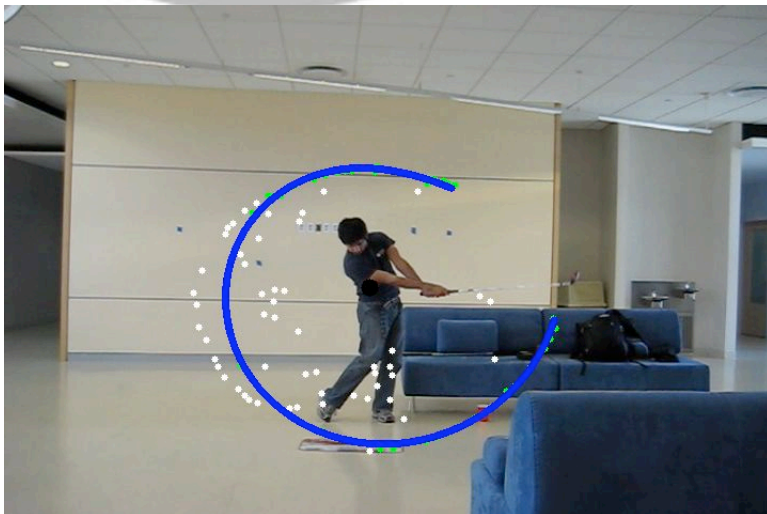


- RANSAC least squares routine to estimate polar curves

- Quality of results varies a lot from video to video

- Need to improve hypotheses or fitting technique

# Guided RANSAC

- In our (small) test suite, extreme $h_i$ in each direction is always good
- Instead of sampling points at random, guide RANSAC to these
- Not always enough though…
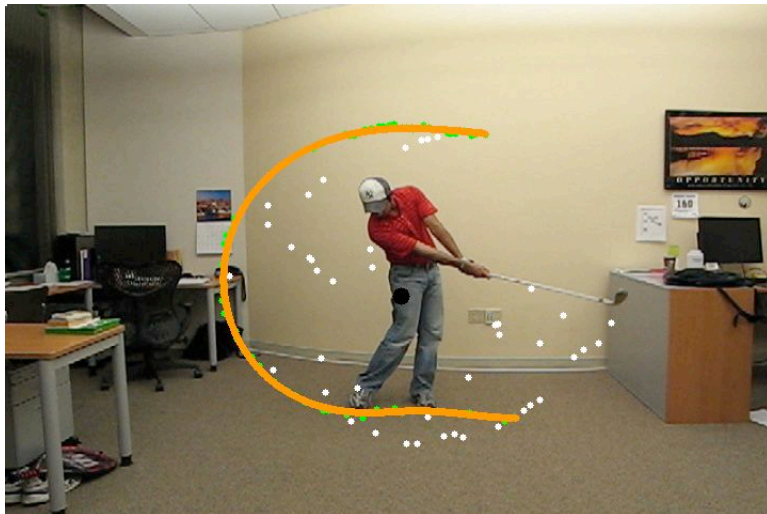
# Superdelegates

- Count the vote of extreme "super points" more than other points

- Overruling the popular vote of RANSAC can backfire (overfitting)

- But shows promise
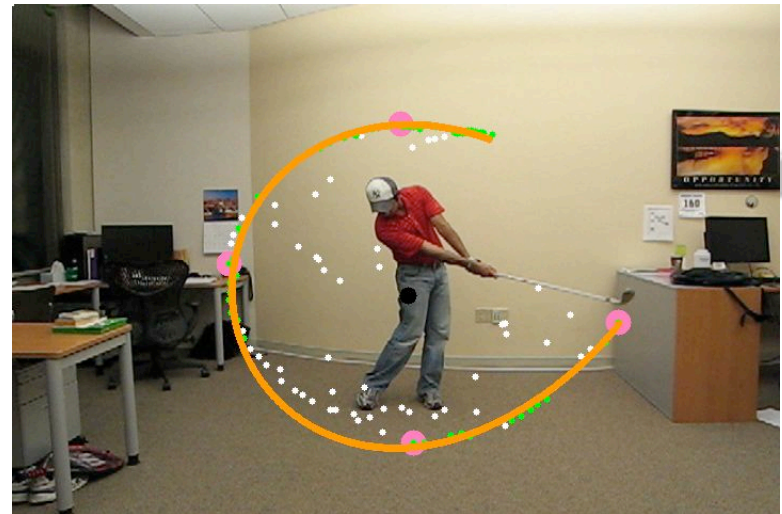
# Time Estimation

- Given the space model from the guided RANSAC, the inliers are used to estimate a time model
- Ordinary RANSAC to estimate angle as a function of time works fairly well

- [demo]

# Future Work

- Improve segment detection
- Improve transition identification
- Accurately offset angles as needed
- Guide RANSAC in "safer" ways

For example, making use of the boundary of the motion history:
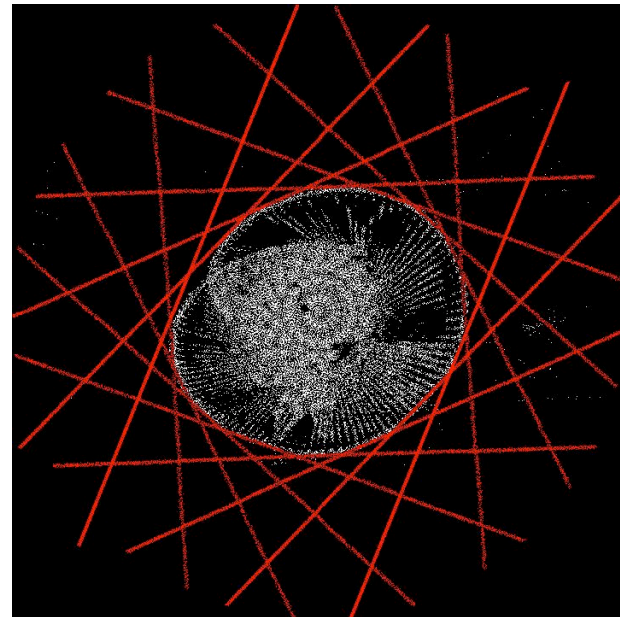
# Future Work

- Obtain larger test corpus
- Consider down-line and up-line angles to reconstruct 3D trajectory
- Tolerance for lower frame rate video
- Tolerance for unstable cameras and backgrounds

- Play more golf