Using Optical Flow for Step Size Initialisation in Hand Tracking by Stochastic Optimisation

Desmond Chik
Background

• ANU-NICTA PhD student working on tracking articulated structures.

• Supervised by
  – Dr Jochen Trumpf
  – Dr Nic Schraudolph
  – Dr Roland Goecke

• Objective of my work
  – To create a real time hand tracker.
Outline

1. Motivation
2. Tracker setup
3. Difficulty in tracking
4. Step size initialisation using optical flow
5. Results
6. Future work
Motivation

- Gestural Interaction
- Sign Language recognition
- Motion capture
Tracker

- 2 precalibrated Sony XCD-710CR colour cameras.
- Video sequences captured at 30fps, resolution 640x480. Video processed offline.

- Model based approach.
- Detailed hand model borrowed from BIWI lab, ETH.
- 26 DOF. skin deformable.
Tracking Algorithm

- Hand pose defined by a set of rotation and translation parameters.

- Sample points taken from hand.

- Points transformed from 3D coordinates to model image planes.

- Silhouette cost function & brightness constancy cost function.
Tracking Algorithm contd.

- Gradients generated by the cost function are back propagated to the parameter space.

- Noise in system due to sampling, image gradients and camera noise.

- SMD (stochastic meta descent) is used to optimise over the parameter space.
SMD

- A fast algorithm for optimising a function using a noisy estimate of the function's true gradient.

\[ w_{t+1} = w_t - p_{t+1} \cdot g_t \]

\[ p_{t+1} = p_t \cdot \max\left(\frac{1}{2}, 1 + \mu v_t \cdot g_t\right), \]

\[ v_{t+1} = \lambda v_t + p_{t+1} \cdot (g_t - \lambda H_t v_t). \]
Difficulty in tracking

• Difficulty lies in kinematic chain of joints in a finger.

• A specific finger movement is achieved by a combination of angle changes along the finger.

• How to decide this combination?

• Errors accumulate over subsequent frames, causing the tracker to lose the pose altogether.
Solution: optical flow

• Use optical flow to determine what initial step size to use.

• Optical flow: in a gripping motion, different parts of the hand move at different speeds.

• One can favor certain joint angles to change by increasing the parameter's initial step size.
Step size initialisation

• Calculate optical flow (Horn & Schunk algorithm) on the image.

• For each hand segment, take sample points and project onto optical flow image.

• Calculate average magnitude of optical flow of that segment.

• Set initial step sizes according to the relative differences in the optical flow between segments.
Step size initialisation cont'd

1. Step size vector $p_k$, for all parameters of joint $k$, are set to a default step size $s$.

2. Scale down the step size for joints that don't move.

$$p_k = \begin{cases} 
  s, & O_k > T_n \\
  \beta s, & \text{otherwise}
\end{cases}$$

where $T_n$ is a threshold, $\beta$ is a scaling factor, $0 < \beta < 1$

5. Adjust step size vector $p_d$ of all parameters of digit $d$, according to ratio of optical flow between each digit $O_d$ & palm $O_p$.

$$p_d = \begin{cases} 
  p \frac{O_d}{T_f}, & \frac{O_d}{\max(O_p, T_n)} > T_f \\
  \beta p_d, & \text{otherwise}
\end{cases}$$
Results

- Testing done on short sequence of 15 frames.
- Scenarios tested:
  - gripping motion
  - spinning motion
  - translating motion
- ~150 sample points used for the tracking.
- Maximum of 100 iterations per frame.
- SMD parameters $\mu = 0.1$, $\lambda = 0.7$. 


Results: gripping motion
Results: spinning motion
Results: translating motion
Future work

• Currently testing on rendered images in OpenGL for a quantitative analysis of the improved performance.

• Refining the step size initialisation scheme.