A Multi-Camera Input Device Utilizing Optical Flow for Ego-motion Estimation

**Overview:**
- **Purpose:** Design a multi-camera input device for electronic media capable of estimating its ego-motion by qualitative analysis of optical flow for gesture recognition (two methods for ego-motion estimation utilized)
- **Method 1:** Compare optical flow data from each camera to a set of synthetic optical flow data, returning corresponding ego-motion parameters
- **Method 2:** Utilize constraints posed by the antipodal regions of the system to estimate the ego-motion for each frame of optical flow

**Prototype:**
- **Design:** Wristband peripheral with four mounted cameras
- **Multi-Camera Advantage:** Disambiguate optical flow ego-motion clues

**Method 1**
- **Generate Optical Flow:** Use modified version of optical flow equations proposed by H. C. Longuet-Higgins [1].

**Algorithm**
- Split each frame into four quadrants, calculating the average optical flow in each quadrant
- Compare averaged data to each synthetically generated case.
- Assume the ego-motion parameters used to generate the case that is closest to the averaged data are the best estimation for that data’s ego-motion
- Repeat the above steps until enough frames have been analyzed to constitute a gesture (in practice 10-20 frames)

**Method 2**
- **Analyzing Antipodal Regions:** This techniques is based on the work of Lim et al [2].

**Algorithm**
- Split each frame into four quadrants, calculating the average optical flow in each quadrant (same as above)
- Project the optical flow vectors from two antipodal regions onto some predefined great circles
- If the signs of those projections are equal, there is a constraint on the direction of the translation; otherwise, there is a constraint on the axis of rotation
- Ego-motion can be estimated from analyzing the constraints proposed above

**Classifying Gestures**
- Method 1: 88.67% Accuracy
- Method 2: 86.67% Accuracy

**Gathering Optical Flow**
- **Optical Flow:** The apparent motion of objects, edges, and surfaces in a visual scene
- **Data:** Calculated for each frame of each camera throughout the duration of the gesture
- **Implementation:** Standard OpenCV

**Citations**
- [1] A Computer Algorithm for Reconstructing a Scene from Two Projections, H.C. Longuet-Higgins, Laboratory of Experimental Psychology, University of Sussex, Brighton BN
- [2] Directions of Ego-motion from Antipodal Points, John Lim, Department of Information Engineering RSISE; Australian National University. Nick Barnes, NICTA, Canberra, Australia