Summary of Eye Gaze Tracking Using an RGBD Compared to RGB

Face-model based methods, with depth camera

RGB Camera coordinate system == world coordinate system

# Algorithm

1. Find transformations from depth camera, and screen, coordinate systems to world coordinate system
   1. Depth to World: using auxiliary camera and predefined pattern [11]
   2. Screen to World: see ref. [12]
2. Through calibration find
   1. eyeball center
   2. eyeball radius
   3. alpha and beta

Initial parameters set to human average. Calibration is achieved through minimization of sum of error angles using COBYLA algorithm.

1. Obtain head pose reference model
2. Estimate gaze:
   1. Calculate world coordinates of eyeball center
      1. Using transformation matrix derived through calibration
   2. Calculate optical axis (eyeball center 🡪 pupil center)
      1. Detect pupil center
         1. Crop eye region
         2. Perform histogram equalization to increase contrast
         3. Construct binary image using thresholding on mean pixel
         4. Run Connected component analysis to remove reflections
         5. Run Gaussian blur
         6. “Emit” 30 rays (horizontally, to ignore eyelids)
         7. Points with highest gradient on ray are considered to be on the ellipse
            1. Remove points with values below certain threshold
         8. Fit ellipse to points
            1. Remove points with fitting error more than 2 STD away from mean
            2. Return to 8
         9. Iris center is considered center of ellipse
   3. Calculate head rotation factor
      1. Track 49 facial landmarks on RGB (using supervised descent method)
      2. Read corresponding 3D points from depth camera
         1. If depth data is missing, estimate using local neighborhood search
      3. Construct 3D face model
         1. Remove points with fitting error more than 2 STD away from mean
         2. Return to iii
      4. Head pose transformation matrix is derived relative to reference model
3. Calculate visual axis using alpha and beta

# Experiments, or – some points of interest

* Data size was doubled by flipping images

# Questions and others

The correct eye model has the visual and optical axis pass through the corneal curvature center instead of the pupil center. The method in the article assumes the optical axis passes through the eyeball center. – can we calculate it somehow using this method?

For section 3,b,i,6: where do they place the seed point?