PupilMetrics Research Manual 1.0

Pupil Analysis Algorithm - Development Synopsis

Project Overview

A mobile Flutter application called **"PupilMetrics Research"** and **"PupilMetrics Neuro"** that implements Professor Bryan K. Marcia's and Bexel Irina clinical research protocols.

The goal is to recreate and improve the functionality of the legacy Bexel Irina and Russian Iridodiagnostic software in a modern mobile platform for pupil analysis and research/educational/clinical purposes.

Core Algorithm Components

1. Iris Detection

- Uses grayscale image processing to locate the iris boundary
- Employs a circle-scoring algorithm that searches for the strongest edge gradient
- Two-pass detection: coarse search followed by fine refinement
- Returns center coordinates, radius, and confidence score

2. Pupil Detection

- Searches within the inner portion of the detected iris
- Uses adaptive thresholding based on the darkest 30% of pixels
- Fits an ellipse to the dark region using covariance matrix eigenvalue decomposition
- Extracts boundary points by ray-casting from center outward
- Returns center, major/minor axes, orientation angle, and boundary points

3. Pupil Boundary Analysis

- Analyzes 72 boundary points (every 5 degrees) around the pupil edge
- Calculates deviation from the average radius at each clock position
- Groups deviations by clock hour (12 zones)
- Identifies **flattenings** (inward deviations) and **protrusions** (outward deviations)

4. ANW (Autonomic Nerve Wreath) Detection

- Searches for gradient changes between pupil edge and mid-iris
- Identifies the collarette boundary
- Calculates ANW ratio relative to iris diameter

Key Measurements Produced

Parameter	Description	Normal Range
P/I Ratio	Pupil diameter as % of iris diameter	20-30%
Ellipseness	Minor/major axis ratio	>95% normal
Circularity	How circular the pupil boundary is	>95% normal
Decentralization	Pupil center offset from iris center	<5% normal
Deformation	Maximum boundary deviation	<5% normal
ANW Ratio	Autonomic nerve wreath position	25-35% normal

Clinical Interpretation Features

Pupil Form Types (PupilMetrics Neuro)

- **Circle** - Normal
- **Oval-Vertical** - Circulatory cerebral disturbances with danger of hemorrhage
- **Oval-Horizontal** - Depressive states, atherosclerosis, asthma predisposition
- **Oval-Diagonal** - Urogenital system disturbances
- **Left Oblique Ellipse** - Urogenital weakness, possible left side paralysis
- **Unilateral Ellipse** - Nervous asthma, bronchus difficulties
- **Ventral Diverging Ellipse** - Leg motility issues, nervous system disturbances
- **Frontal Diverging Ellipse** - Brain insult risk, anxiety, muscle spasms

Decentration Patterns

- **Frontal** - Mental/cerebral issues
- **Basal** - Leg motility, nervous system
- **Nasal** - Lung pathology (right eye) / Cardiac issues (left eye)
- **Temporal** - Nephritis, orchitis, salpingitis
- **Middle-Nasal** - Oxygen deficiency, cardiospastic risk
- **Upper-Nasal** - Mental disorders, spinal irritation
- And 8 more directional patterns...

Zone-Specific Organ Associations

Each of the 8 pupil zones has specific organ associations for:

- **Flattenings** - Indicating hypofunction/weakness
- **Protrusions** - Indicating hyperfunction/irritation

Associations differ between right eye (OD) and left eye (OS) per CNRI protocols.

Application Features

Analysis Screen

- Real-time eye validation before analysis
- Progress indicator during processing
- Displays all measurements with color-coded status
- Shows organ associations for detected anomalies
- Full descriptions for Pupil Form and Decentration Patterns

Reports Generated

1. **On-Screen Results** - Interactive cards with expandable details
2. **TXT Report** - Plain text with Bexel-style diagnosis section
3. **JSON Report** - Structured data for integration/archival
4. **PDF Report** - Professional formatted document with images

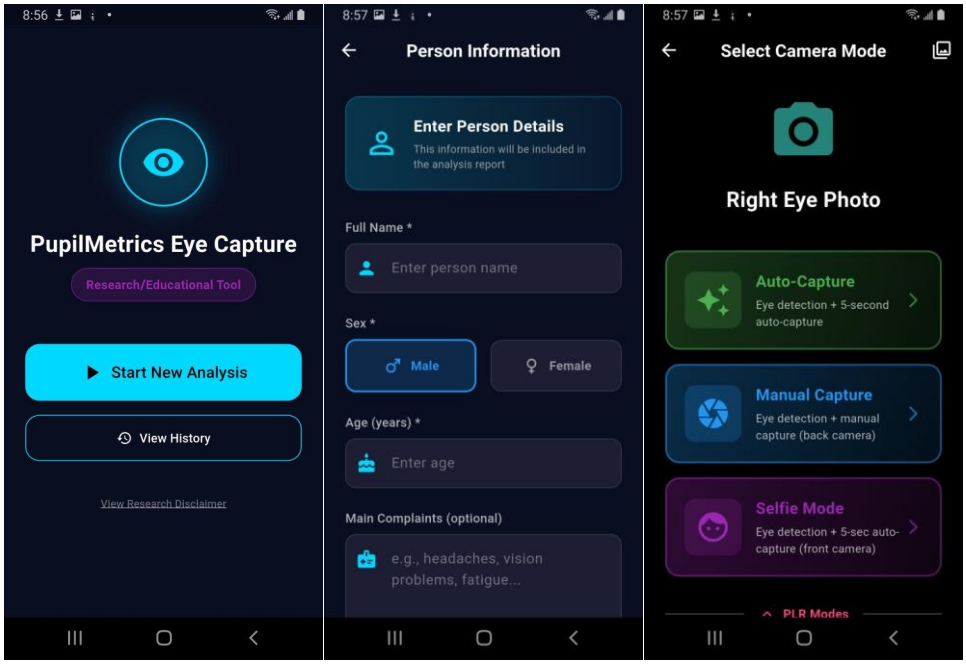
Additional Features

- Anisocoria detection with TBI (Traumatic Brain Injury) indicator (Neuro-Version)
- Age-based pupil size assessment
- Bilateral comparison between eyes
- Scan history with database storage
- PLR (Pupillary Light Reflex) analysis

All Metrics Now Displayed (Research Version):

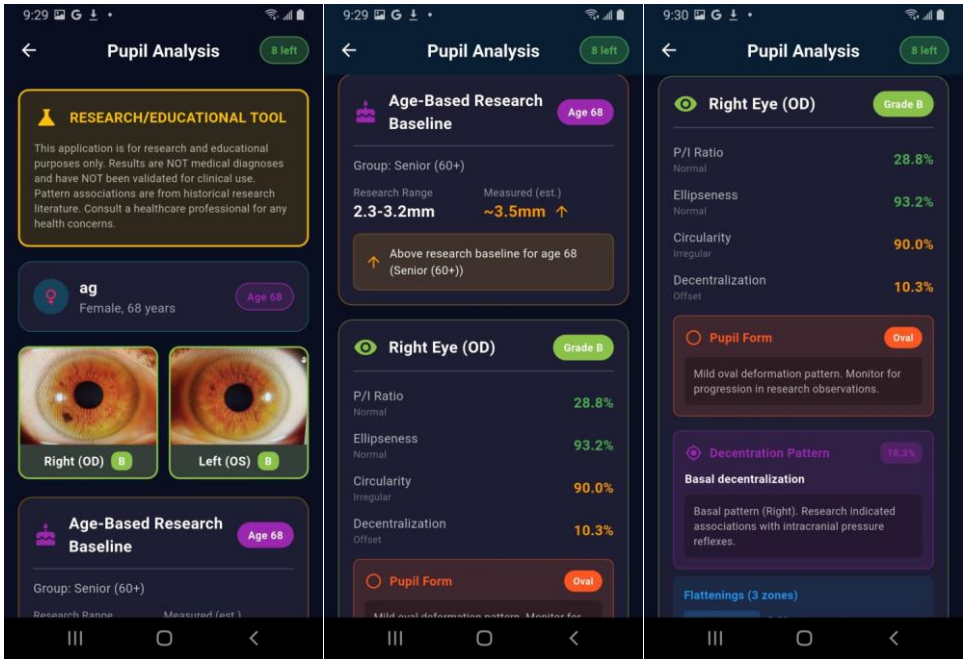
Metric	Description
P/I Ratio	Pupil/Iris ratio with status (Normal/Miosis/Mydriasis)
Ellipseness	With status (Normal/Elliptical)
Circularity	With status (Regular/Irregular)
Decentration	With status (Normal/Offset)
Deformation	Pupil border deformation %
Confidence	Detection confidence with label
ANW Ratio	If detected
Pupil Form	Circle/Oval/Chord/Irregular
Deformation Angle	In degrees with zone
Zone Info Box	Zone name + organ association
Flattenings	Each zone with %, severity color, organ
Protrusions	Each zone with %, severity color, organ

PupilMetrics Application Screenshot Samples

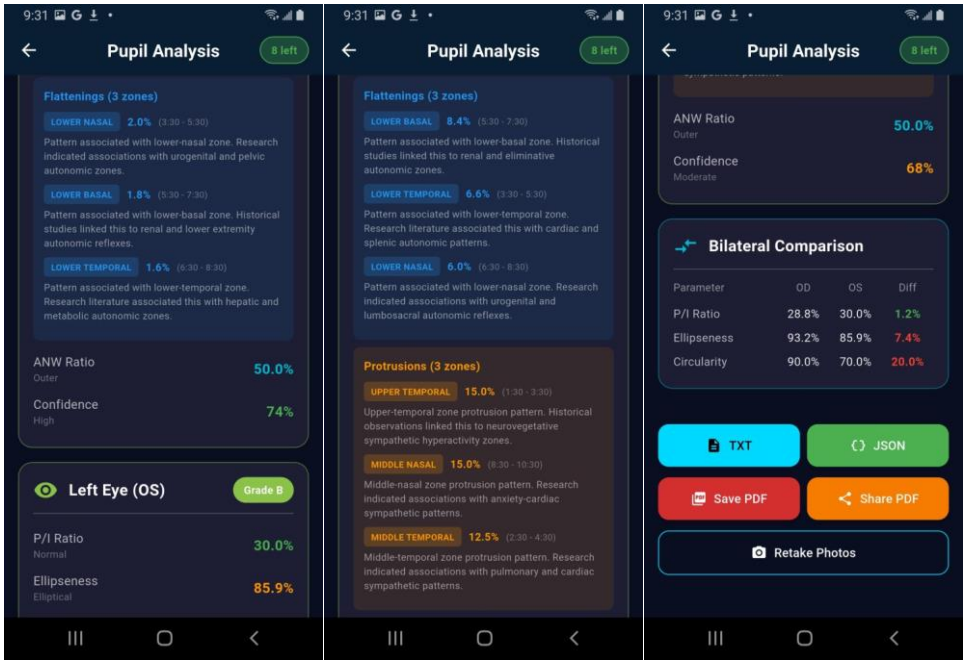


The PupilMetrics app's startup screen provides options to begin a new analysis or view previous client assessments.

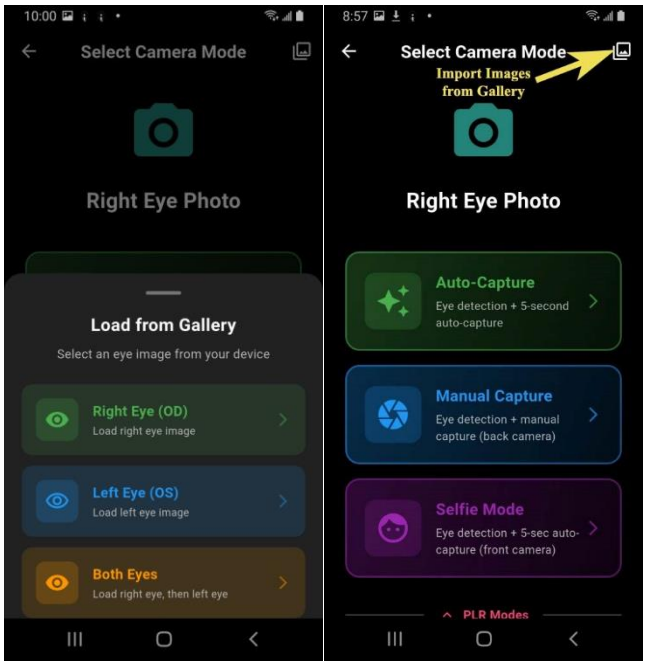
Pupil Assessment Results I



Pupil Assessment Results II

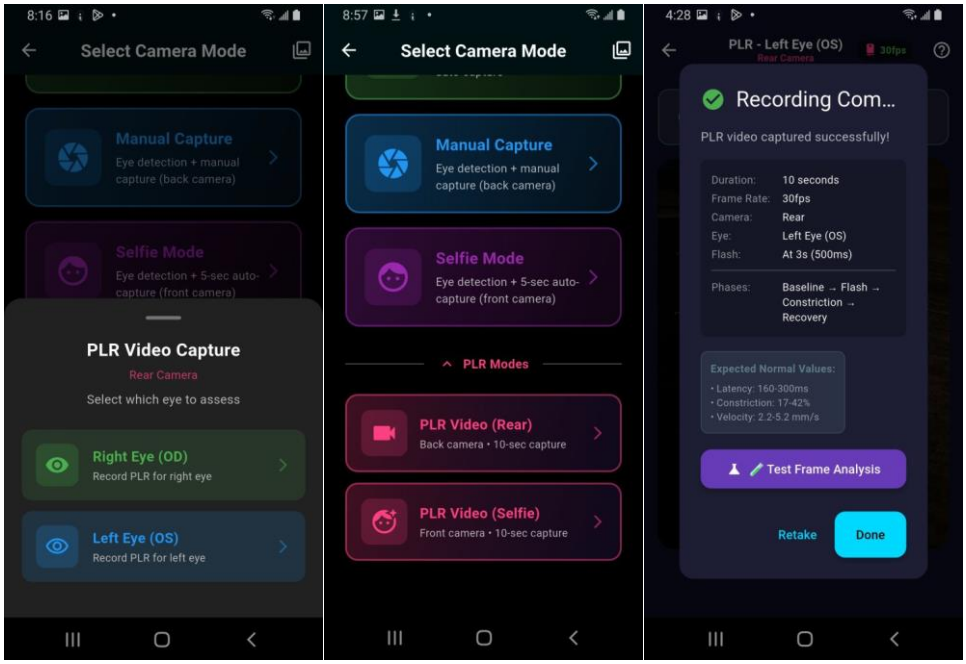


Pupil Eye Image Importation



On the camera mode selector screen, tap the small graphic icon button in the top-right corner to import eye images. You can import both eyes at the same time. **Important:** Do not capture eyes from a computer screen! Always use live eyes or imported eye images only. Capturing from screens introduces noise, confuses the detection algorithm, and can lead to inconsistent results.

PLR Analysis



PLR (Pupillary Light Reflex) video scan PLR analysis reveals autonomic nervous system imbalances (parasympathetic/sympathetic), aiding in detecting neurodegenerative diseases (e.g., Parkinson's), concussion/mild TBI, fatigue, or effects of substances (e.g., alcohol, opioids). It also serves as a biomarker for conditions like multiple sclerosis or diabetic retinopathy. Video still-frames can also be downloaded to users gallery for importing into static pupil analysis.

PLR Metrics Applied

| Metric | Description | Normal Range |

|--------|-------------|--------------|

| **Baseline Diameter** | Resting pupil size before stimulus | 3-5mm |

| **Latency** | Time from light onset to constriction start | 180-300ms |

| **Constriction Velocity** | Rate of pupil constriction | 3-5 mm/sec |

| **Max Constriction %** | Percentage reduction from baseline | 30-50% |

| **Minimum Diameter** | Smallest pupil size achieved | - |

| **Time to Minimum** | Duration to reach max constriction | 0.5-1.0 sec |

| **Dilation Velocity** | Rate of return to baseline | 1-2 mm/sec |

| **75% Recovery Time** | Time to recover 75% of baseline | 2-5 sec |

| **PIPR (Post-Illumination)** | Sustained constriction after light off | Melanopsin indicator |