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iRecHS2

Operation code

2014/07/17

National Institute of Advanced Industrial
Science and Technology (AIST) Human Life Technology Research
Institute Systems Brain Science Research Group

Keiji Matsuda

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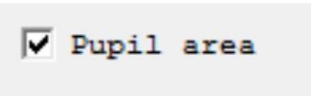
1. Threshold adjustment

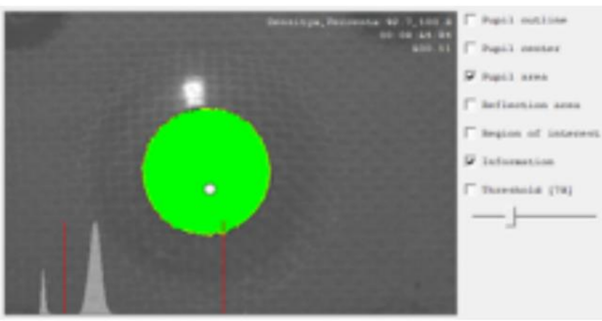
In pupil detection, a place in an image where the brightness is below a certain value is considered to be the pupil. Therefore, determining the threshold is a very important item for pupil detection. Although it is possible to determine the threshold automatically, a fixed value may be preferable if the ambient light changes little. I would like you to select an appropriate method by trial and error. If you want to change the threshold value automatically, first open the menu bar Window->Option window and check Use previous data (this switch works effectively when the pupil is hidden by the eyelid) Therefore, it is recommended to operate with the checkbox checked even if the threshold is not changed automatically). If the dynamic threshold determination fails, the manually determined value is used, so be sure to set the threshold manually even if the threshold is automatically changed.

By checking the check box in front of Threshold, Threshold becomes a fixed value. The current threshold is the number written in brackets (38 in the above case).



By checking the Pupil area check box, the area below the threshold is displayed in green, so check it when changing the threshold. By moving the slide bar, you can see that the place below the threshold changes as follows.

The middle figure, where only the pupil is below the threshold, is the optimal setting. When operating with a fixed value, uncheck before Threshold if you want the threshold to follow automatically.
By checking Information, you can see the histogram of the image and the current threshold value. The red bar on the left represents the current threshold, and the highlighted area is the luminance histogram. Since the pupil appears as the first peak, it can be seen that the valley past the first peak is an appropriate threshold.



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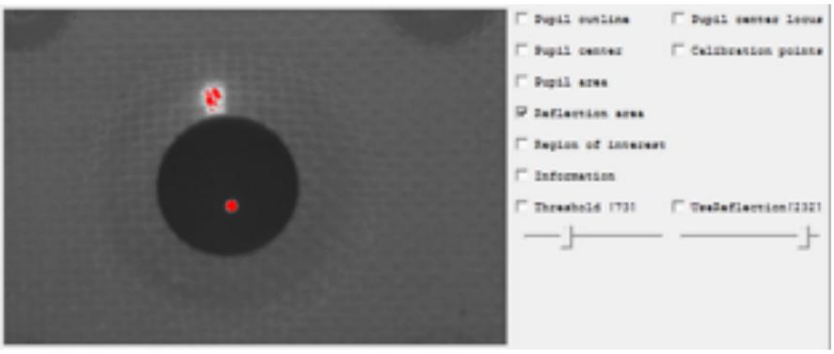
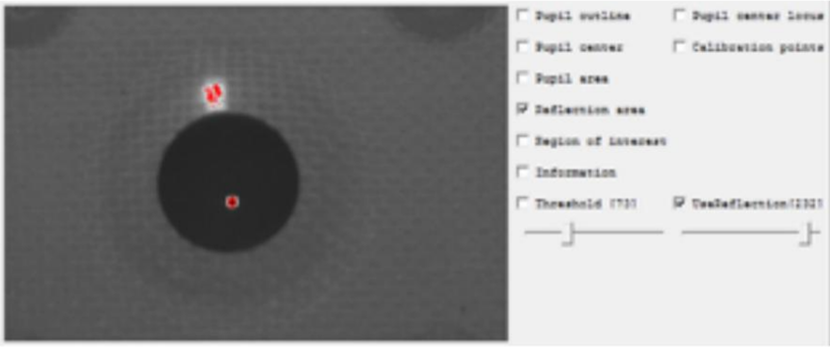
2. Adjustment of reflection point threshold

It is used to correct the movement of the head by using the illumination light reflected on the cornea. Since there is no function to automatically set the threshold of the reflection point, the fixed value specified with the slide bar is used. If you do not want to use this function, set the slide bar to the far right (255). If a reflection point is used, adjust the position of the illumination so that the reflection point is placed on the cornea.



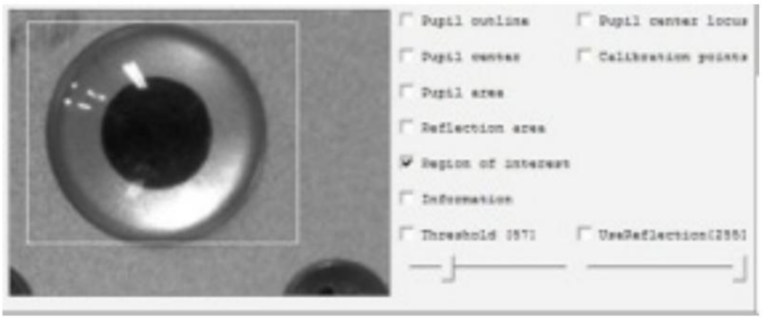
If you put a check in Reflection area, the place where the brightness is higher than the threshold of the reflection point is displayed in red.



If UseReflection is checked, the place selected as the reflection point is displayed as a white square with the center of gravity at 10 o'clock.

3. Setting ROI (Region of Interest)

Only the inside of the set ROI is treated as the pupil detection area. By selecting only the necessary areas, it is possible to improve the calculation speed and accuracy. If you put a check in Region of interest, you can check the current area. Press the left mouse button at the edge of the area you want to select and drag to determine the range. Since the set range is written to setting.txt after the program ends, measurement can be performed within the determined range the next time the program is started.



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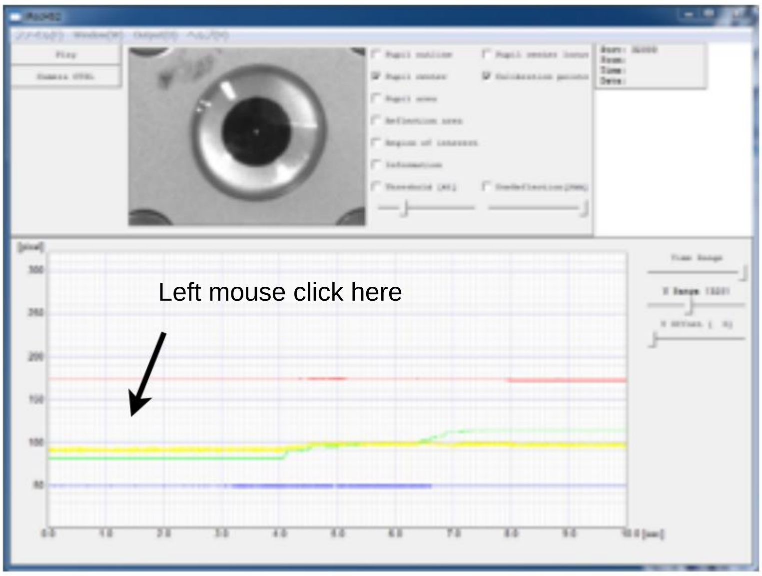
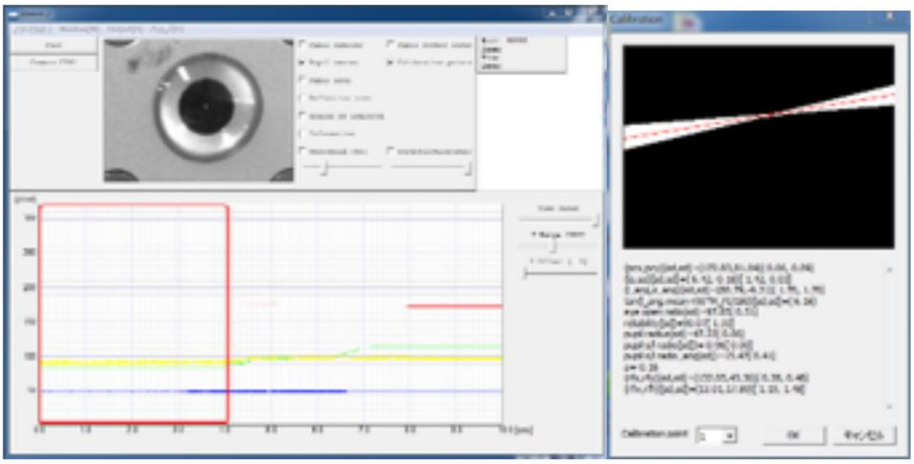
4. By having the active

calibration subject (subject) gaze at the visual target, it becomes possible to calculate the line-of-sight direction in the object coordinate system for the visual target. Set Output to CameraPosition.

1. After confirming the fixation of the **registration target 1 of the calibration point by mouse click ,** click the corresponding place with the mouse.



When clicked, it will be in a pause state (measurement will also be interrupted). It is also possible to press the Pause button to make it pause, and then click on the relevant part. Automatically detect the part where the line of sight is gazing at one point near the clicked part. At the same time, a window opens asking if the location can be used as a calibration point.



The red frame part is the selected area. The window shows the overlaid tilt of the minor axis when the pupil is approximated by an ellipse (white) and its average value (red). The lower pull-down list Calibration point shows the numbers of target visual targets. By changing this numerical value, the corresponding target can be changed. If there is no problem, press OK to store the calibration points. If there is a point on this graph where another calibration point is being viewed, left-click on that point. If there is no problem, press OK to store the calibration point

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2. Registration of calibration points with the return

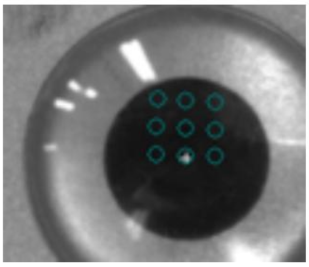
key The calibration points can be registered by pressing the return key at the same time as confirming that the subject saw the visual target. Equivalent to clicking the left mouse button 300 ms before pressing the key.

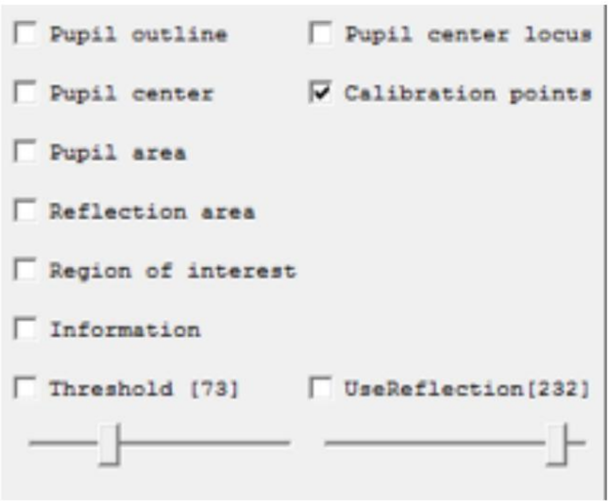
3. When there are

no more calibration points on the visual target fixation screen, press the upper left Play button to have the subject fixate on the next calibration point. The above is repeated until the fixation of all fixation points is finished.

4. If you put a check mark in the optotype calibration

points that are superimposed on the image, the pupil center position corresponding to the position of the optotype can be displayed superimposed on the image . If the visual target is not on a straight line, it appears at the third point. In the figure below, it is displayed overlapping with the image looking at the 8th gaze point.





5. Passive calibration Used

when measuring the line of sight of a subject (subject) who cannot perform active calibration. You will be able to calculate the line of sight in the camera coordinate system where the line connecting the camera and the center of eyeball rotation is the z-axis (x, y-axes are lines parallel to the x- and y-axes of the camera and passing through the center of eyeball rotation). Used to measure the line of sight of marmosets, mice, etc. Necessary parameters for calculation are obtained from the image of moving the eyeball with respect to the camera. Set Output to CameraPosition.

1. Check eye movements After

enough eye movements have been recorded, press the pause button to pause the measurement.

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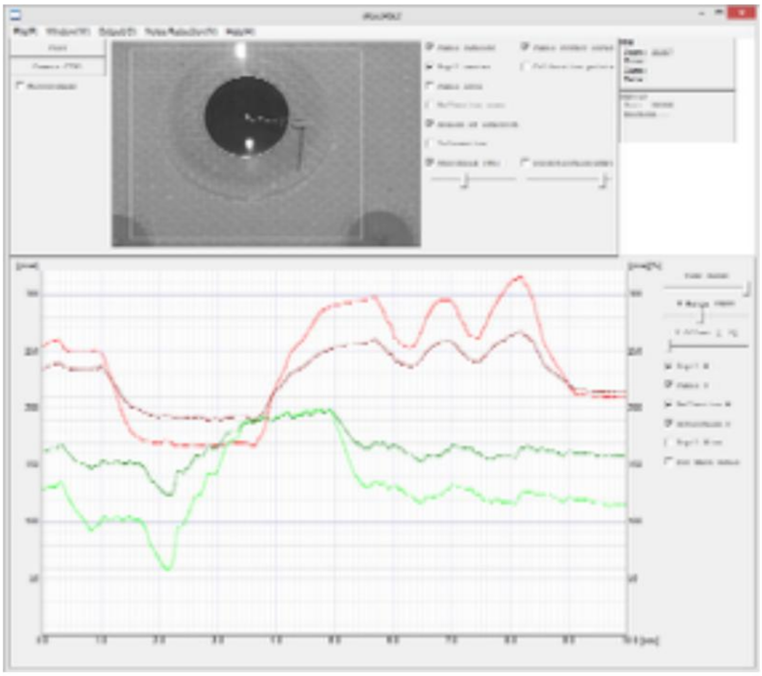
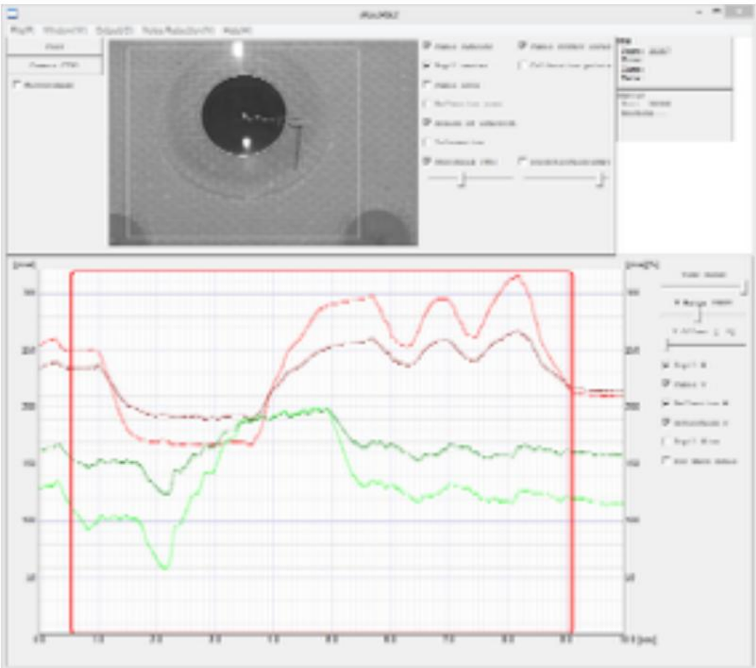


2. Specify the range to be used for

proofreading While pressing the right mouse button, drag to specify the range.



3. Display of calibration

result The calibration result will be displayed. If there is no problem, press OK. This completes the passive calibration and allows presentation of the line of sight in the camera coordinate system. The blue line is the trajectory of the center of the pupil. The white line is an extension of the short axis when approximating the pupil with an ellipse. The brightness increases as it passes through the same place. The red ten o'clock represents the center of eyeball rotation.

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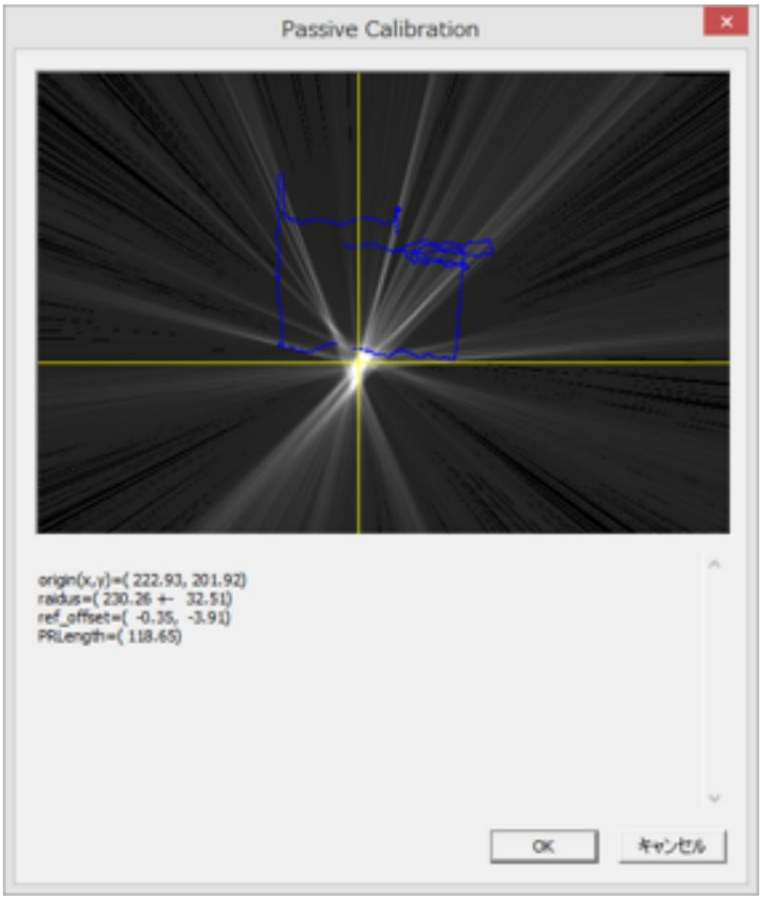
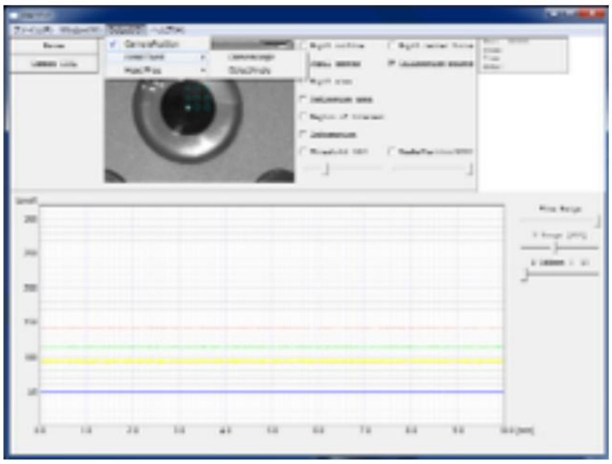


6. Output switching When the

calibration is completed, you can select the eyeball angle output in Output. If calibration has not been completed, the menu will be grayed out and cannot be selected. Switching is possible at the stage when the coordinate system conversion matrix can be calculated without performing calibration for all targets. From the point of view of accuracy, it is better to calibrate using as many targets as possible. DAC output also switches to angle output at the same time. AO0 is set to x (red line in the figure above), and AO1 is set to y (green lin The pupil radius (blue line) is output to AO2, and the eye opening rate (yellow line) is output to AO3. Since the simulated eyeball used in the screenshot on the next page could not be calibrated using reflection points, The object coordinate system ObjectAngle in HeadFree is displayed in gray and cannot be selected. Calibration can be performed only when Output is CameraPosition.



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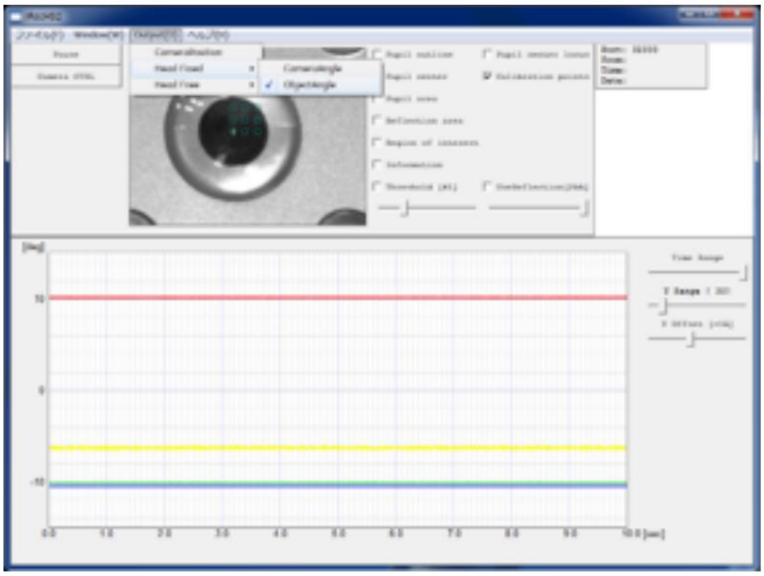
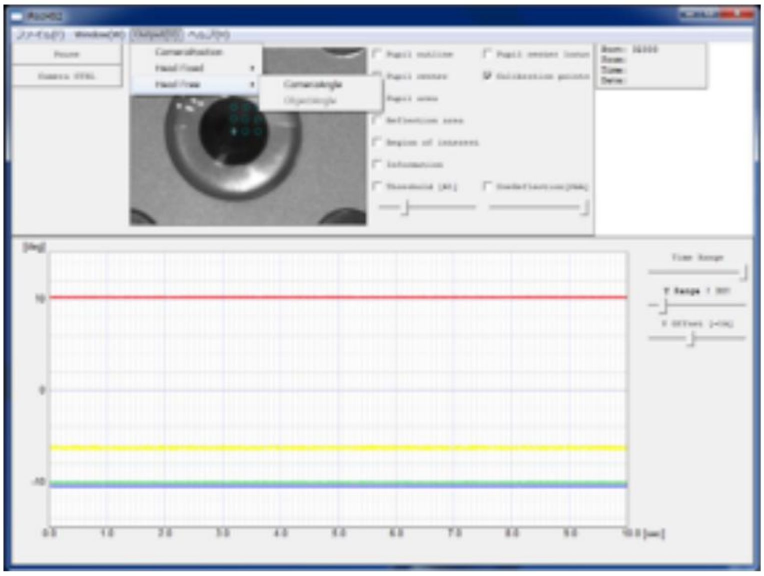
Select head fixed-object coordinate system.

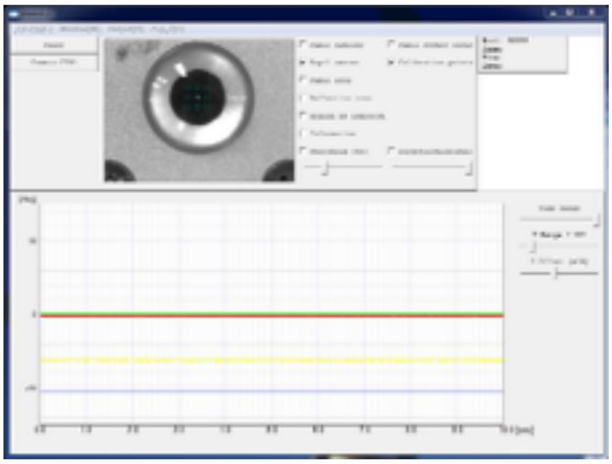


Unfixed head - Object coordinate system cannot be selected.

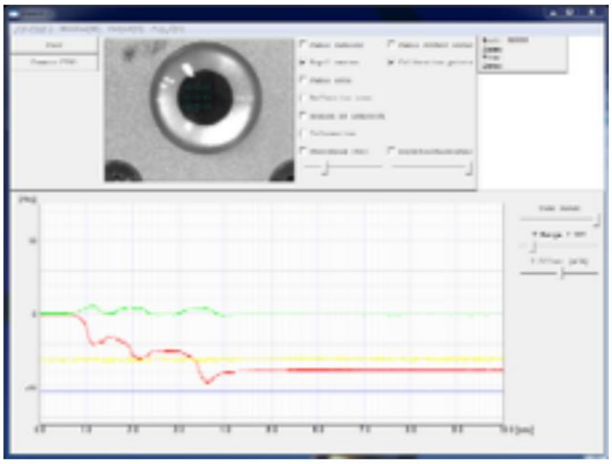


7. Recalibration in Head Fix

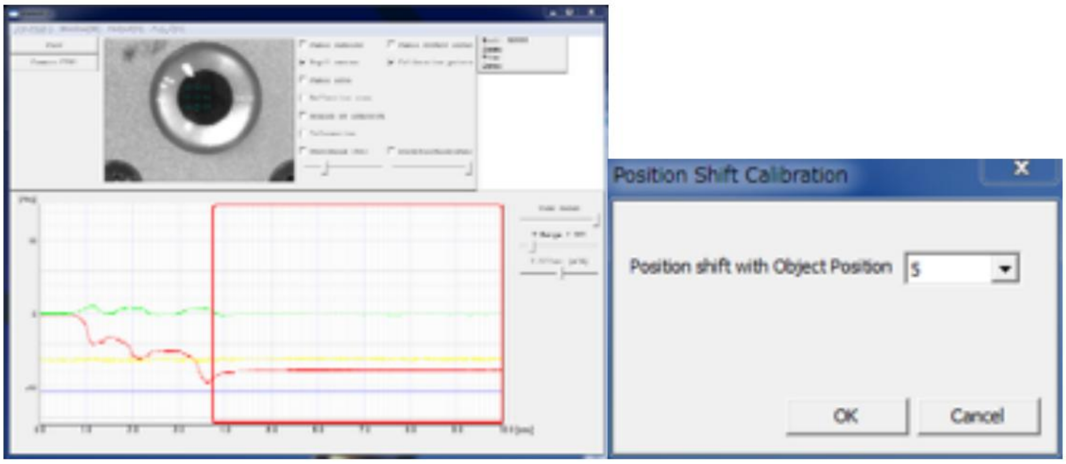
Correction when the subject moves subtly with respect to the camera. Correction is performed by translating the eyeball rotation center position. Specifically, the target is re-presented to the subject, and the amount of movement is calculated at the position when the subject is gazing at that point. This recalibration can be done when Output is Head Fixed-ObjectAngle. When looking at the central optotype.



The object has moved for some reason (in the figure, the camera has been translated)



I'm supposed to be looking at the center, but the measured values are moving a lot. Click with the left mouse button on the flat part on the right.



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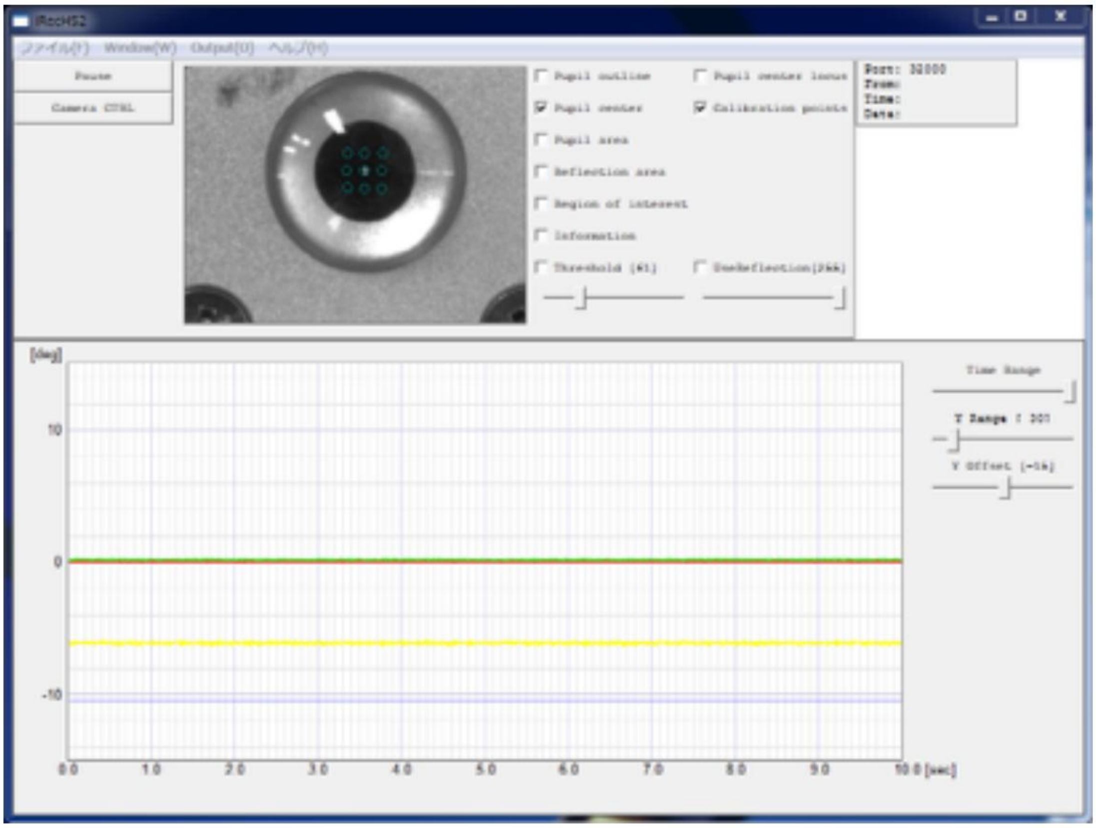
It is assumed that the part surrounded by the red frame is looking at the fifth visual target. Press OK and press the Play button to resume the measurement.



Looking at the center, you can see that it has been recalibrated.

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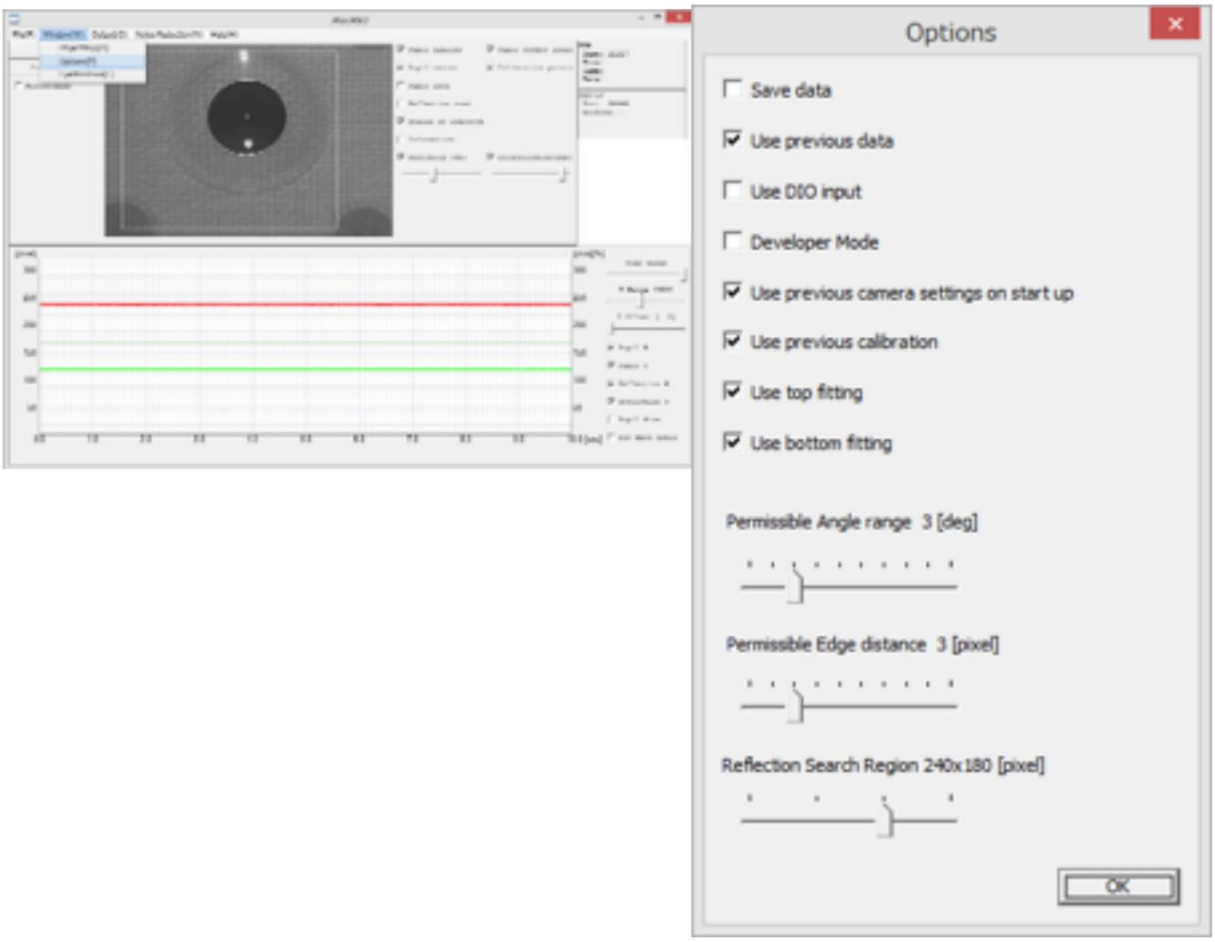
8. About calibration at the start of the experiment

Accurate measurement requires calibration each time, but if the camera position/illumination position/subject are the same, the second and subsequent calibrations can be simplified.

Open the Options dialog from Window->Options, check Use previous camera settings on start up and Use previous calibration, and press OK. This will write the camera settings and calibration results to setting.txt at the end of the program. In the case of Head Fix, re-calibrate one visual target as described in the previous chapter. In the case of Head Free, you can start using it without proofreading. If the camera or lighting has moved, or if the subject is different, you can overwrite the previous calibration result by switching Output to Camera Position and performing calibration for the number of registered targets. .



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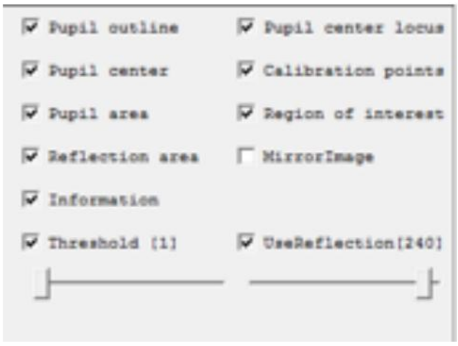
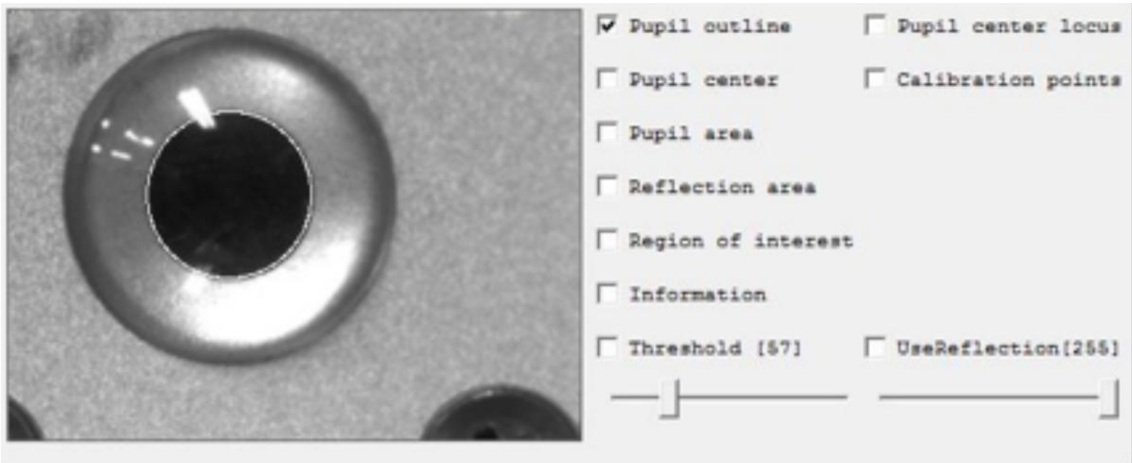
9. Information display check box on camera image

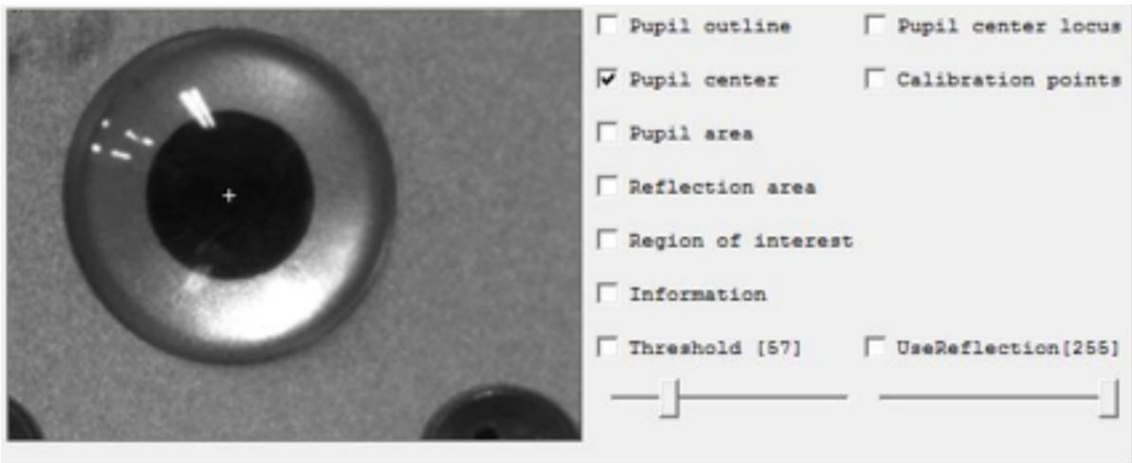
By checking the above check box, various information can be superimposed and displayed on the camera input image. Changing these settings has no effect on the measurement data. Since the display order is fixed, some information may be overwritten and not displayed.



1. Pupil outline Display
an ellipse when approximating the pupil with an ellipse.



2. Pupil center A cross
is displayed at the center of the ellipse when the pupil is approximated by an ellipse.



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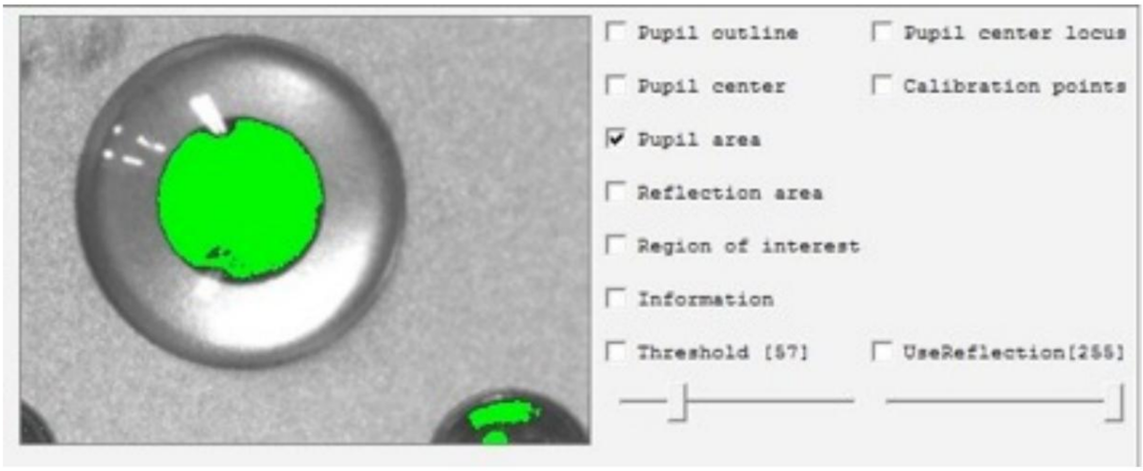
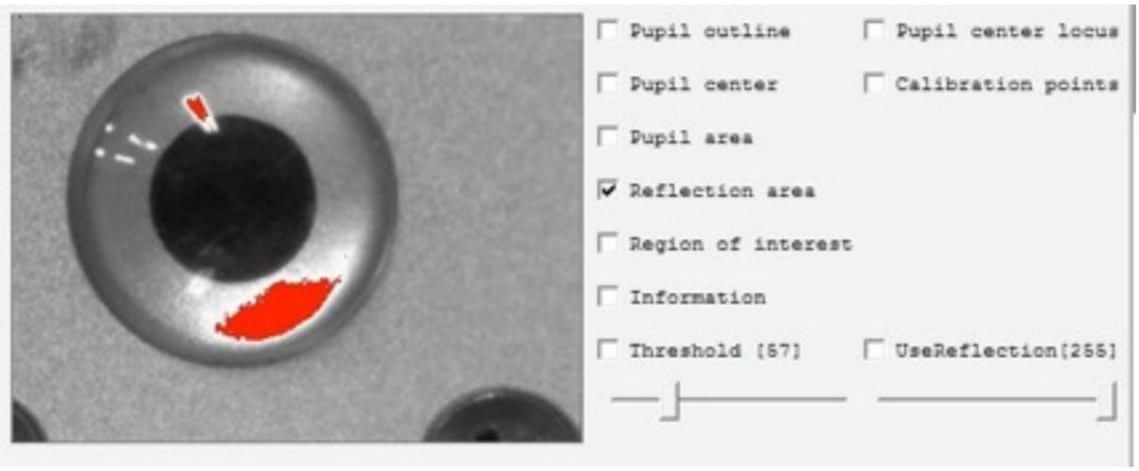
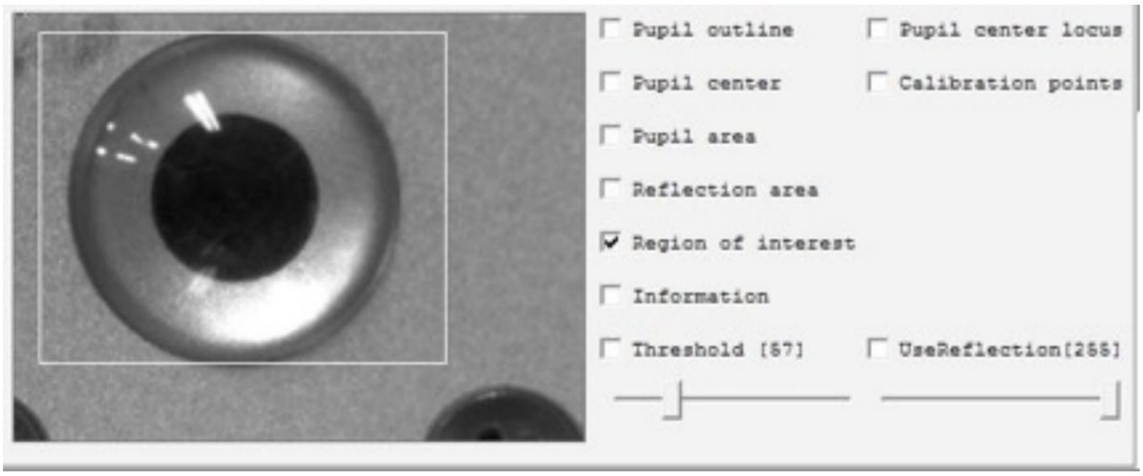
3. Areas lower
than the Pupil area Threshold are painted green. Threshold is the value if Threshold is checked (57 in the figure below). If not checked, the calculated value is used. See Threshold section.



4. Areas larger than
the value set in **Reflection area** UseReflection are painted in red.



5. Display the detection range
of **the Region of interest** image with a white frame. The position of the white frame (ROI) can be changed by pressing the left mouse button and dragging. See measurement preparation section.



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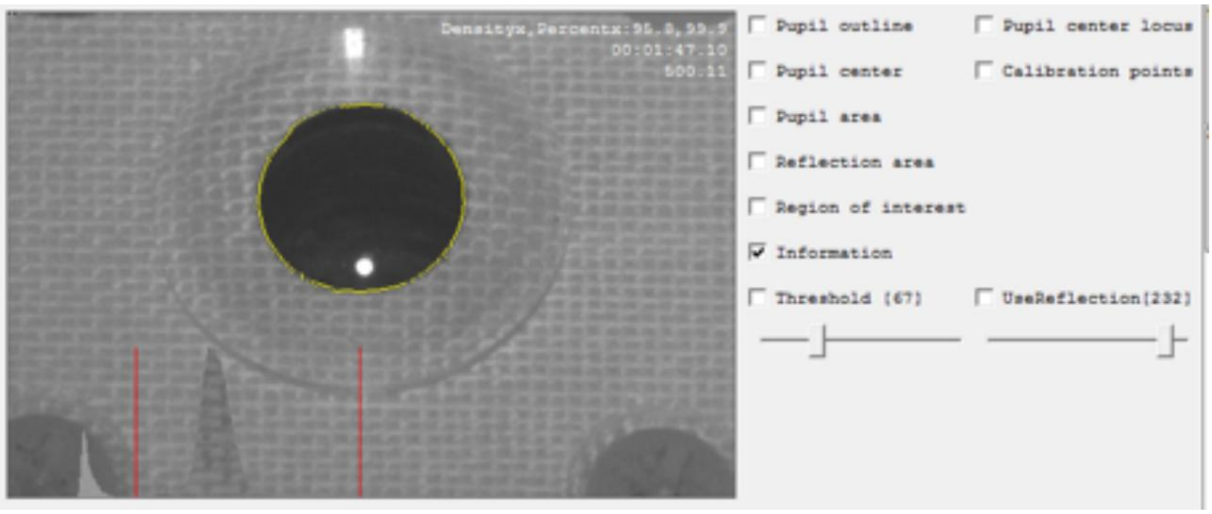
6. Information

Display of various information. Various displays are used for program debugging. Since it is provisional, what is displayed may change in the future.



Upper right

character) Densityx, Persentx: 95.8, 99.9

Expresses that Densityx is 95.8% and Percentx is 99.9%.

Densityx represents what percentage of the detected pupil edge is used for ellipse approximation.

Percentx represents (maximum value of pupil margin yÿminimum value)/length of ellipse in y direction*100.

The yellow line in the graph below shows Percentx. 00:1:47.10 represents the time from the start of measurement. (1 minute 47 seconds 40). 500.11 represents the current image acquisition frequency (500.11 Hz). Pupil Rim Yellow Pupil rim used for pupil approximation. Lower left image brightness inverted part.

Histograms of ROI intensity are fitted. X-axis is luminance value. The left end is 0, and the 255th pixel from the left is the maximum luminance value. bottom left red line

Threshold for calculating the display image. right red line

Reflection point threshold for display image.

The number of display items in this area will be increased or decreased as necessary in the future.

7. Pupil center locus Displays the locus of pupil center coordinates. Plot the latest 2550 images or images within 10 seconds so that the newer ones are brighter. In case of capture at 334Hz, 2550/334 = 7.6 seconds worth of trajectory. In the case of 250Hz, the trajectory is 10 seconds.

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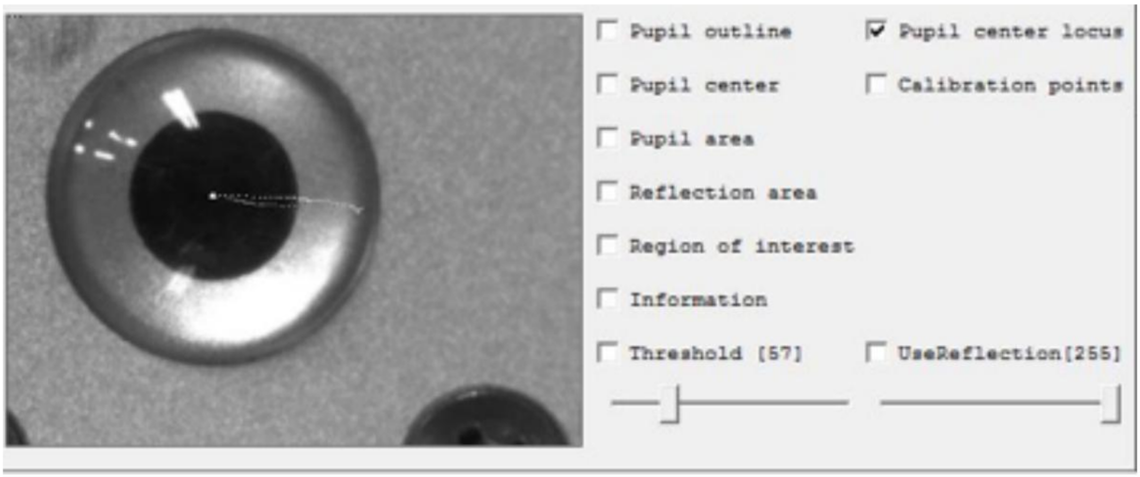
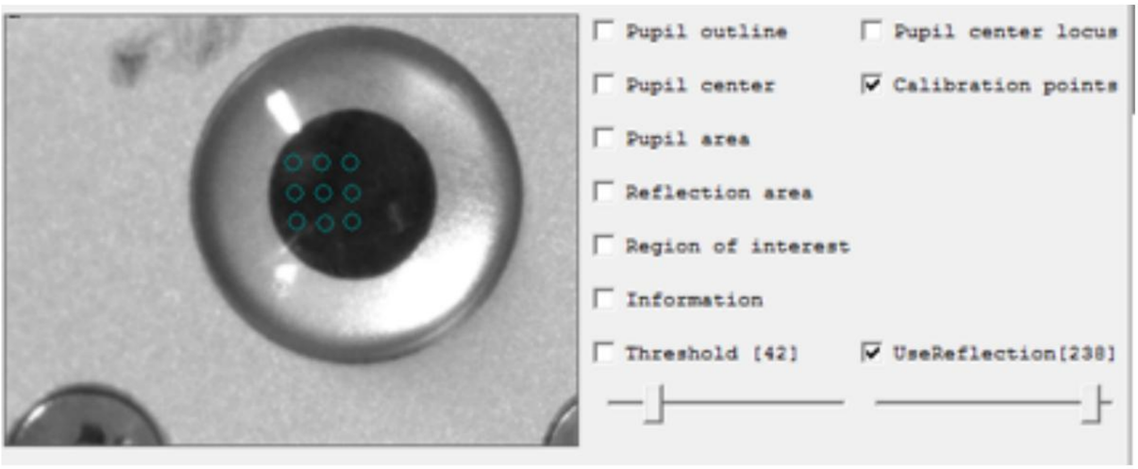


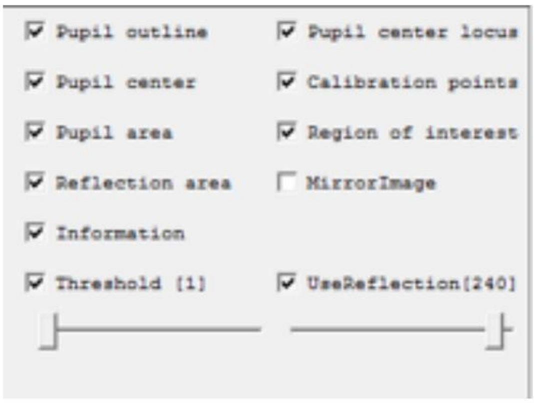
8. Calibration points After
calibration of the necessary calibration points (minimum 3 points for calibration points not distributed on a straight line), each calibration point (points registered in the Object Map) assuming that the head is fixed) is indicated by a circle with a radius of 5 pixels. See calibration section.

When Output is HeadFree ObjectAngle, it displays the pupil center position corresponding to the calibration point according to the movement of the head.



9. MirrorImage

Check this to display the image input as a mirror image. When photographing your own eyes
By performing mirror image display, the direction of movement and the direction of display can be matched.



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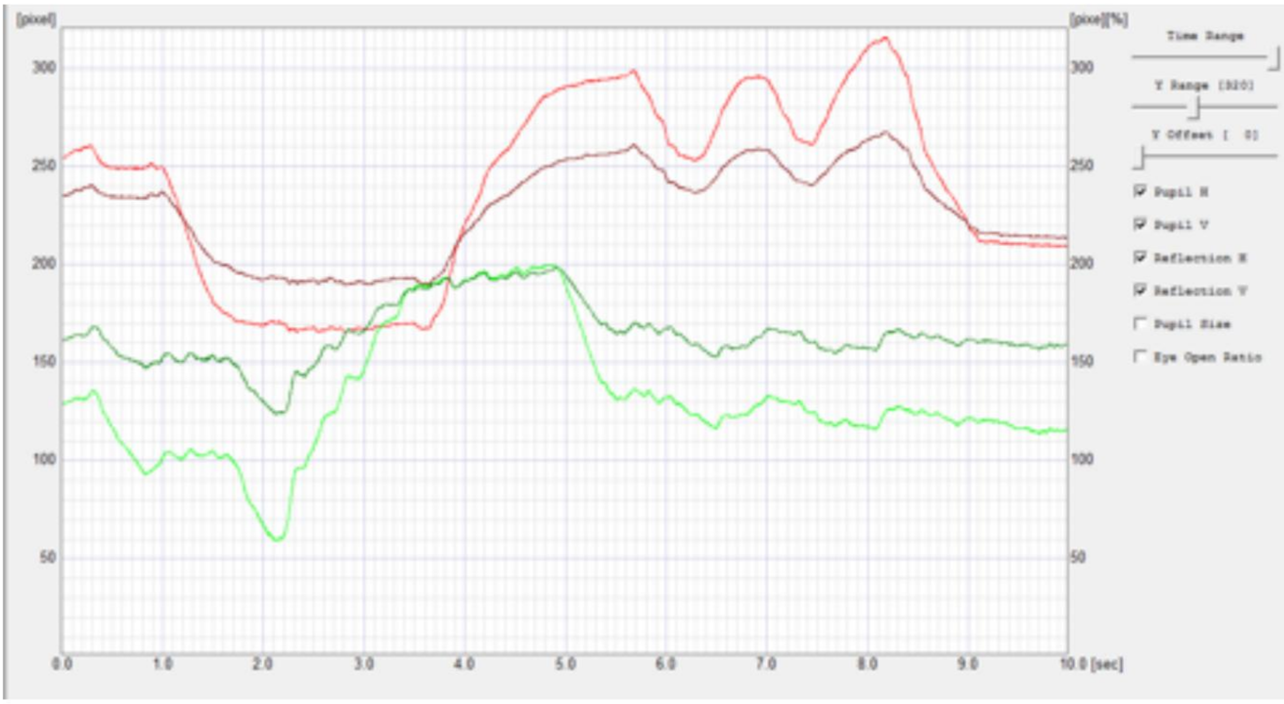
10. About graph display 1. Display

target (changes in conjunction with Output on the menu bar) You can turn on/off the display by turning on/off the check box.



Output->CameraPosition The upper left corner of the image is the origin (0,0).

Pupil H Pupil center (x) Unit is pixel, Color Red RGB[255,0,0]

Pupil V pupil center (y) unit is pixel, color green RGB[0,255,0]

Reflection H Reflection point centroid (x) Unit is pixel, dark red RGB[128,0,0]

Reflection V Reflection point centroid (y) Unit is pixel, dark green RGB[0,128,0]

Pupil Size Pupil radius Unit is pixel, Color Blue RGB[0,0,255]

Eye Open Ratio The unit is %,

Percentage of eye opening = Vertical length of measured pupil/Vertical length of ellipse *100 Percentx displayed when Information is checked. Display color Yellow RGB[0255,255,0]

Display targets **other than Output->CameraPosition** are eyeball rotation angle, pupil radius, and eye opening ratio.

Pupil H Eye rotation angle (x) Unit is deg, Color Red RGB[255,0,0]

Pupil V eyeball rotation angle (y) unit is deg, color green RGB[0,255,0]

In the case of CameraAngle, the origin is the leg of the perpendicular drawn from the eyeball to the camera plane.

ObjectAngle is the origin by setting the target.

ReflectionH/V is not displayed in this mode. Pupil Size/Eye Open Ratio is Same as CameraPosition.

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2. Graph horizontal

axis The horizontal axis represents the time axis. By moving the Time Range slider on the right side, you can change the width of the displayed time from 1 second to 10 seconds in 1 second increments. Changing the slider during measurement does not affect the measurement, but the longer the display time, the greater the load on the computer.

3. The left vertical

axis of the graph The vertical axis represents the position of the center of the pupil, the position of the center of gravity of the reflection point, and the rotation angle of the eyeball. You can change the display width by moving the Y Range slide bar on the right. Changing the slider during measurement has no effect on the measurement. The change width is from 10[pixel] to the maximum input width of the camera (640 in Grasshopper) for the position, and from 10[deg] to 180[deg] for the angle. You can change the bottom edge of the Y axis by moving the Y Offset slide bar on the right. For position, the bottom edge can be changed from 0 to 640-Y Range. For angle, the lower end can be changed from -90 to 90-Y Range.

4. The vertical axis on

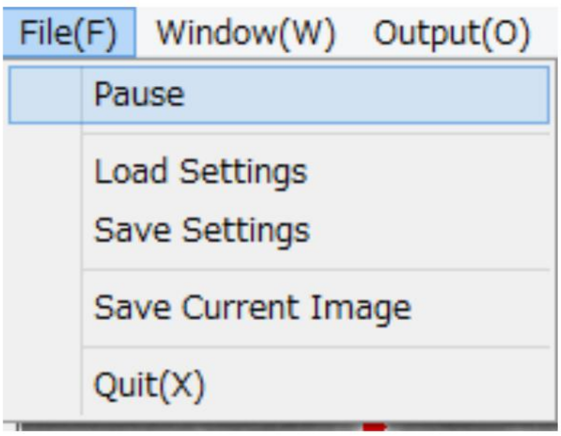
the right side of the graph is the same as the vertical axis on the left side of the graph at startup (Y Range 320/Y Offset 0), and represents the pupil radius/eye opening ratio (units are pixel and %, respectively). Changing the Y Range/Y Offset slide bars does not change the display of these values.

5. You can

expand the graph area by pressing the maximize button on the upper right of the other window. Can be expanded up to 2560x1600. As the display area increases, the load on the computer increases. Start Task Manager, and if the CPU usage seems to be too high, it may be a good idea to adjust it.

11. Menu

1. File



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Pause

Select Pause to pause image input/image processing. No data is collected during suspension. The data just before pressing the Pause button is continuously output to the DAC. Select again to resume image input/image processing. The same operation is possible with the ESC button on the keyboard. If the focus is on the slider that adjusts the threshold, etc. (the slider is surrounded by a dotted line), the ESC button will not be enabled unless the focus is removed.

Load Settings

Normally, the settings described in setting.txt in the same directory as iRecHS2.exe are loaded at startup, but this is used when you want to load other settings. It also changes the settings of the DAC, so care must be taken when handling it. All parameters may not be updated, so if you expect reliable operation, replace setting.txt and restart.

Save Settings

Normally, a file called setting.txt is created in the same directory as iRecHS2.exe when exiting, and the state set in the program is saved in it.

Save Current Image

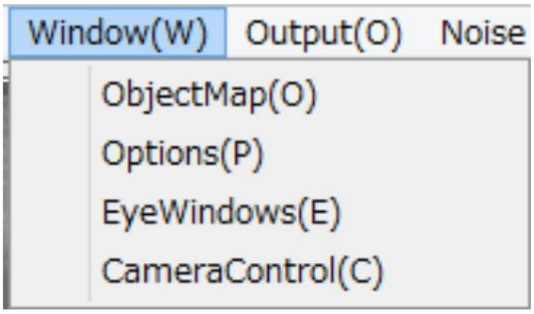
iRecHS2.exe stores the latest 4000 camera images in memory. Used when writing these images to disk. Measurement, etc. is interrupted during writing. Interruption time can be shortened by using fast-writing devices such as SSD. The destination is home directory\iRecHS2\Image\date\time\.
The date is 20121206, the time is 150826, and so on. The file name uses the frame counter value. The frame counter is a serial number starting from 0 when the power of the camera is turned on.
Images are in uncompressed bitmap format. Don't panic if it hangs because it takes a long time to write.

Quit

Exit the application. Write the setting status to setting.txt when finished. If Save data is checked in Option settings, data will be written. If Develop Mode is checked in Option settings, more detailed data will be written. It may take a certain amount of time to complete the measurement if the measurement is performed for a long time because it takes time to write the data. If you force quit, the data export will be cut off in the middle, so be careful.

If "No" is pressed, the measurement is continued.

2. Window

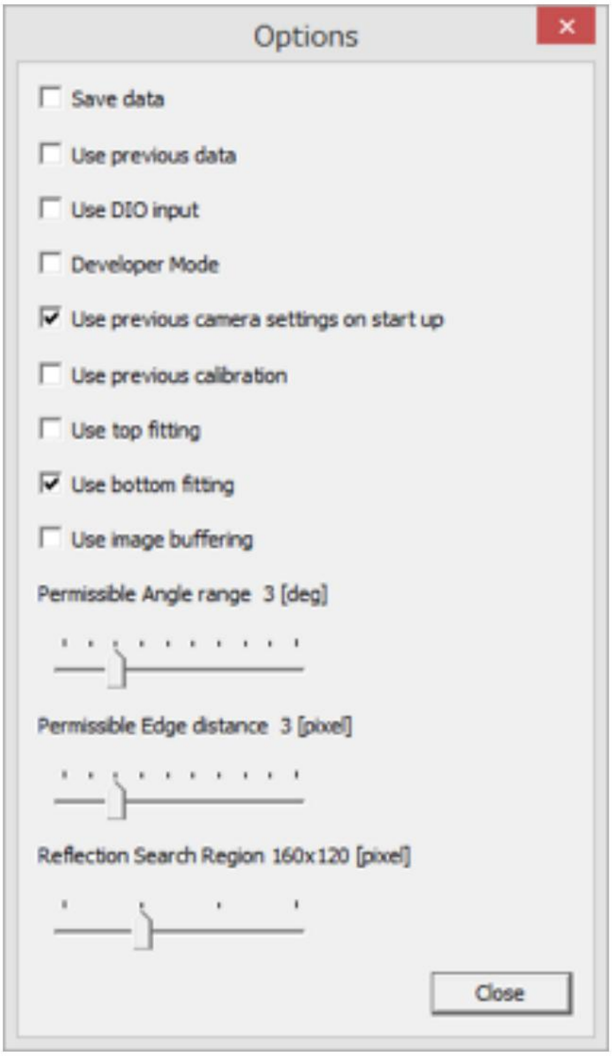


Register target

positions used for **ObjectMap(O)** calibration. Input in the order in which the visual targets are presented. The number of targets should be at least 3 if the targets are not distributed on a straight line, but it is desirable to use 5 or 9 so as to cover the measurement range. Refer to Chapter 3 Registration of Calibration Points in Setting Edition.

Options (P)

Make various settings. The result of setting is recorded in setting.txt.



If **Save data** is

checked, the experimental data will be written when the program ends. The data to be written are time, pupil center position during the experiment (before calibration)/gaze direction (calibration).

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post-blation), pupil diameter, DIO status (if Use DIO input is checked), and output mode. The export destination is home directory\iRecHS2\DATA\date\time.csv. The date is "20121206" and the time is "154937". Since it is a comma-separated text, it can be read into Excel, etc. The character code is UTF-8. For this reason, if you read it with Excel mac2011, half-width katakana will be entered in the first cell. If you are concerned about it, convert it to Shift-JIS with an editor and read it.

If **the Use previous data**
check box is checked, the pupil image information obtained in the previous frame is used when detecting the pupil. Normally, it is desirable to perform measurement with this item checked.

Use DIO input
Reads the status of AO-1604L-LPE connector 7 (DI 00)/6 (DI 01)/5 (DI 02)/4 (DI 03) at the timing of camera image acquisition. . If Save data is checked, write the status to a file. The data is represented by a numerical value from 0 to 15, with (DI 00) as 0 bit/(DI 01) as 1 bit/(DI 02) as 2 bits/(DI 03) as 3rd bit.

Developer Mode If this
item and Save data are checked, more detailed experimental data will be written out when the program ends. Refer to the header of the actual file, as the content to be written varies depending on the development content. The write destination is home directory\iRecHS2\DATA\date\time dev.csv. The date is "20121206" and the time is "154937". Since it is a comma-delimited text, it can be read into Excel, etc. Character code is UTF-8. Character code is UTF-8. For this reason, if you read it with Excel mac2011, half-width katakana will be entered in the first cell. If it bothers you, convert it to Shift-JIS with an editor and read it.

Use previous camera settings on start up Write camera
input settings (Mode/Image position (Left/Top/Width/Height)/FrameRate) to setting.txt. The next time you start, start with these values read. Recommended to use with On.

Use previous calibration Write the
calibration values (pupil rotation radius, pupil rotation center, reflection point offset amount, corneal curvature rotation radius, coordinate system conversion matrix) to setting.txt. The next time it starts, it will start with these values read. Set to On at the same time as Use previous camera settings on start up above.
(In the next update, it will be fixed so that it cannot be selected when the above is off).

Use top fitting The
horizontal pupil edge is used when approximating the pupil with an ellipse. With this method, the upper and lower rim portions of the pupil are not utilized. When top fitting is turned on, the upper border of the pupil is detected. If the upper part of the pupil is hidden by the eyelid, better results can be obtained by turning it off.

Use bottom fitting Uses
the bottom edge of the pupil when approximating the pupil with an ellipse. Normally, use with on. If there is a problem, turn it off. By turning on Information, the

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can be visualized in yellow. If an abnormal part is clearly detected, turn it off.

Use image buffering

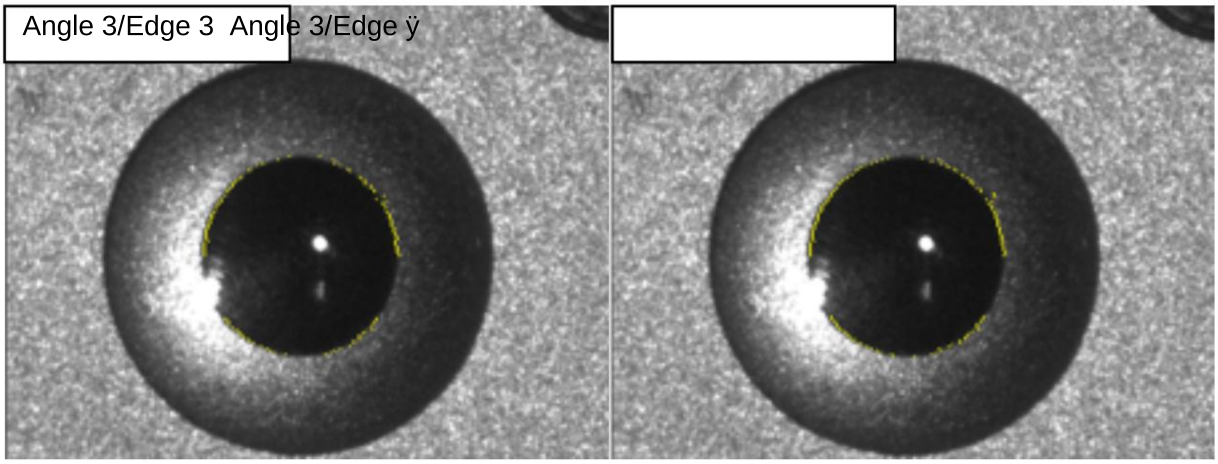
Enable Buffer frame mode when inputting images (usually Drop frame mode). Although it becomes difficult for processing failure to occur, responsiveness deteriorates. See the Flycapture2API manual for details.

The geometry of the ellipse is used to remove noise when doing **permissible angle range** pupil detection. The edges of the pupil are sampled parallel to the screen, and the slope of a straight line connecting the midpoints is used. Sets the allowable tilt range. Initial value is 3[deg].

Permissible Edge distance After filtering with the permissible range of inclination, gleaning is performed. Set the range for gleaning. Initial value is 3[pixel]

Noise removal

state The part that looks yellow is the part that was adopted as the pupil edge. See how it changes when you change each value. The smaller these values are, the more accurate the ellipse approximation is. At present, the initial value of 3 seems to be good for each. If there are many irregularities on the edges, such as the pupil of a mouse, the ellipse approximation will be stable by dividing each value by 5/5. Looking at the elliptical approximation of the simulated eyeball, it can be seen that 5/5 are affected by noise compared to 3/3.



You can see how the noise is picked up in the upper right.

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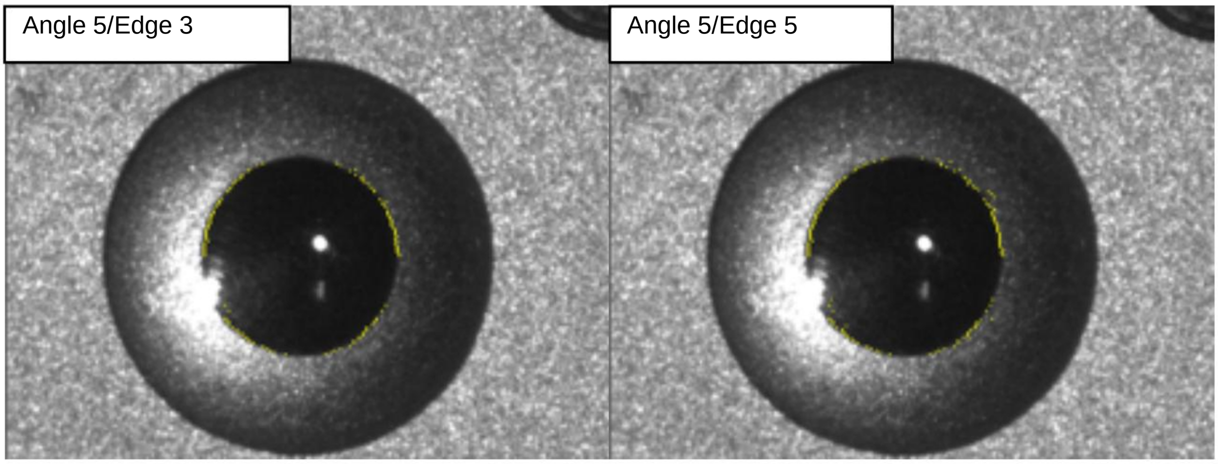
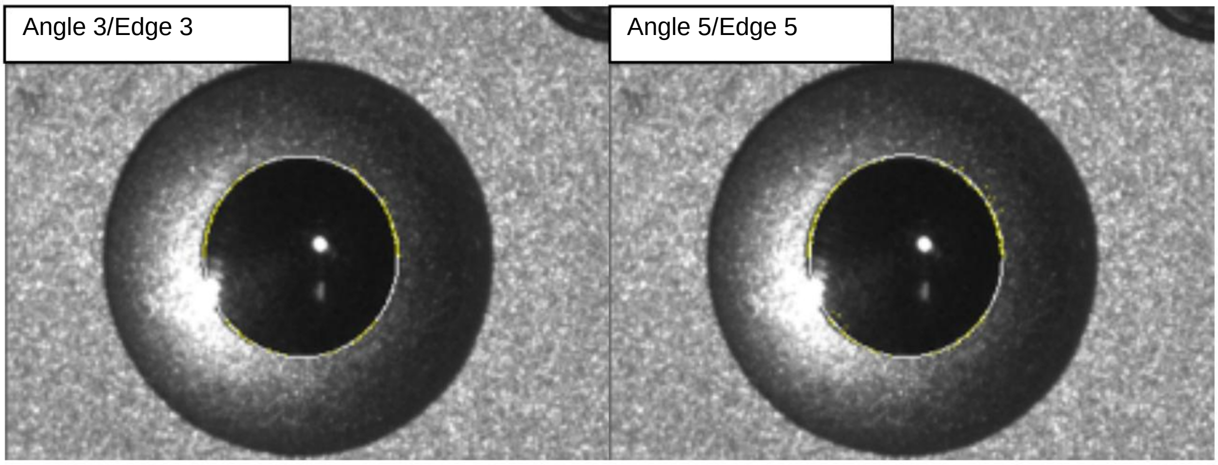


Comparing 3/3 and 5/3, you can see how noise is picked up around the lower left bright point. Comparing 3/3 and 5/5 shows an increase in the amount of noise. When elliptical approximation is performed with the noise included, the result is as follows.



It can be seen that the size of the gap around the lower left bright point is 5/5 larger.

Reflection Search Region Reflection point search range. A group of bright points above the threshold that are located within a rectangular range of display size with the center of the pupil as the center and that is the closest to the center of the pupil is defined as a reflection point. If the reflection point cannot be captured well, try expanding the area. If the area is too wide, other points will be misidentified or speed will be reduced, so set it appropriately.

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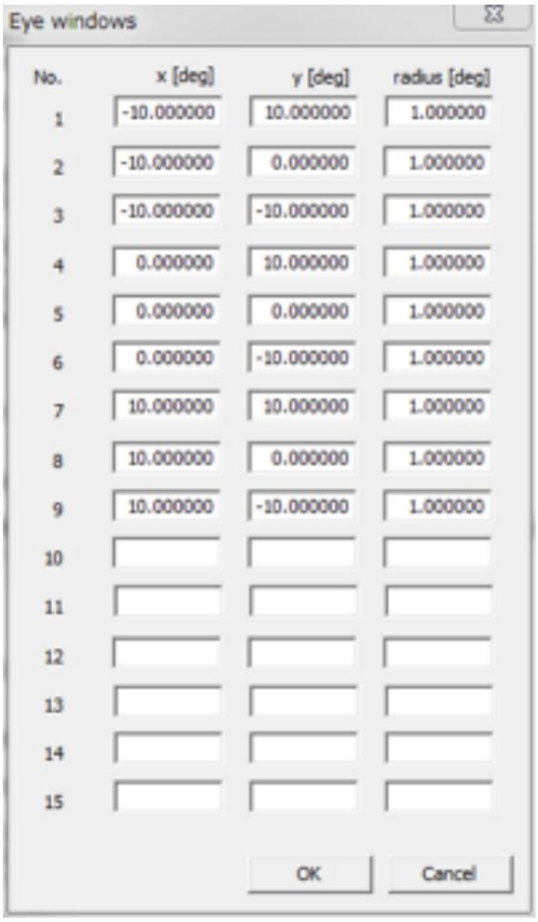
For Windows



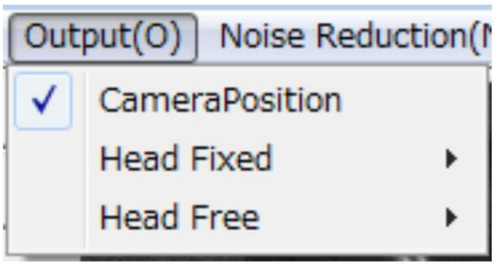
Set the eye window. The shape of the window is a circle. When the line of sight enters the set window, DIO outputs the data corresponding to No. (In the case of 3, it becomes 0011, so it becomes ch0-1, ch1-1, ch2-0, ch3-0). If the window positions overlap, the value of the smaller window is printed. 0 is always output when the output mode is CameraPosition.

Open the

CameraControl camera settings dialog. The display of this dialog affects the measurement (process drop occurs). Do not display dialogs unless necessary. Press this menu again or close the dialog with the close button of the dialog.

3. Switch

output contents to **Output** DAC, output contents to Save data, and graph display. The amplitude of the voltage will be the one set in the initial dialog.



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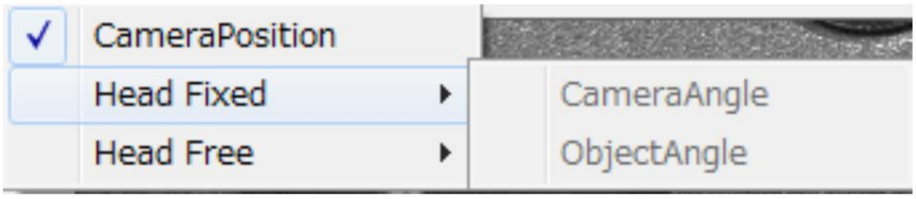
CameraPosition

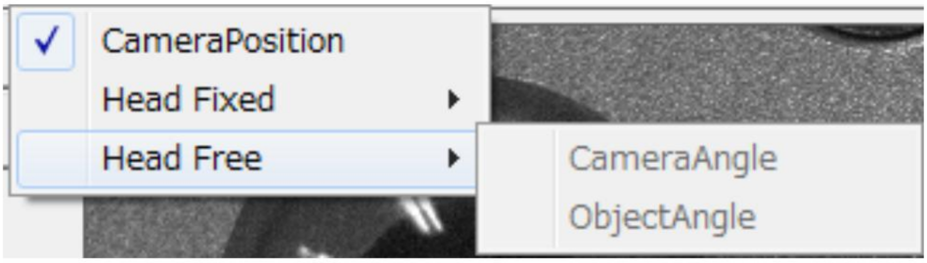
A pupil center position is represented by pixel data. The top left is (0,0). Let the horizontal direction be x and the vertical direction be y. Minimum value of DAC when 0. The maximum value of x or y is the maximum value of DAC. If the input image is 320x240 pixels, the maximum value of x is 319 and the maximum value of y is 239, so 319 corresponds to the maximum value of DAC +10V. Save data describes x,y pixel values and 0 in mode.

Cannot be selected unless **Head Fixed-CameraAngle** calibration is completed. It shows the angle by which the eyeball rotates in the camera coordinate system. Save data mode is 1.



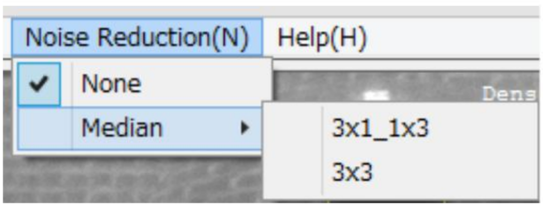
Cannot be selected unless **Head Fixed-ObjectAngle** calibration is completed. The degree of rotation of the eyeball in the calibrated target coordinate system is shown in terms of angle. Save data mode is 2.

Cannot be selected unless **Head Free-CameraAngle** calibration is completed. It shows the angle by which the eyeball rotates in the camera coordinate system. Save data mode is 3.



Selection is not possible unless **Head Free-ObjectAngle** calibration is completed. The degree of rotation of the eyeball in the calibrated target coordinate system is shown in terms of angle. Save data mode is 4.

4. Noise Reduction



For noisy images, apply a median filter when detecting edges. 3x1_3x1 takes the median of 3 pixels horizontally and then the median of 3 pixels vertically. Selected pixels

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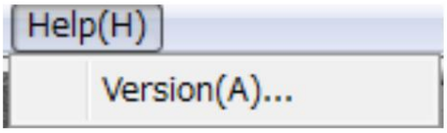
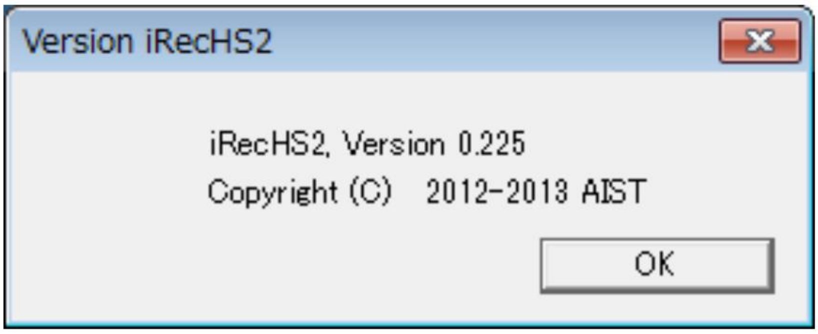
le will be either 4th, 5th or 6th. 3x3 is the 5th among 9 pixels. Since 3x3 has a larger amount of computation, there is a possibility that processing omissions may occur.

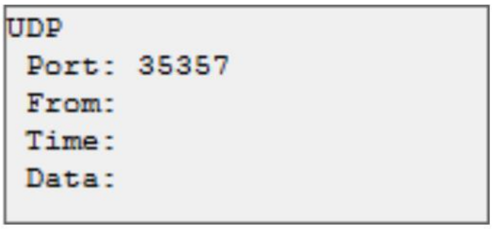
5. Help



Display version information/copyright.

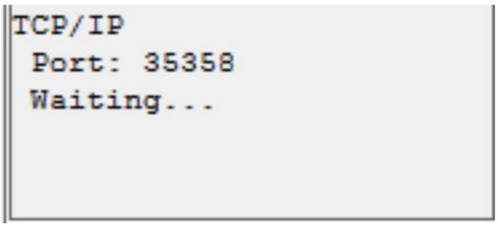


12. About network input



A 32bit integer can be received via UDP. The received data is written to a file called home directory\iRecHS2\DATA\date\timenet.csv when the program ends. Also, in the above text area, indicate where, when and what kind of data arrived. Overwritten with the most recent data. The port address is 35357.

13. About network output



Data can be output via TCP/IP. The data has the same format as Save data. Combined with Presentation (http://www.neurobs.com/), it is possible to construct an experimental environment such as presenting visual stimuli at the line of sight . It is possible to provide a presentation scenario that presents a cross at the line of sight.