Retinal Imaging

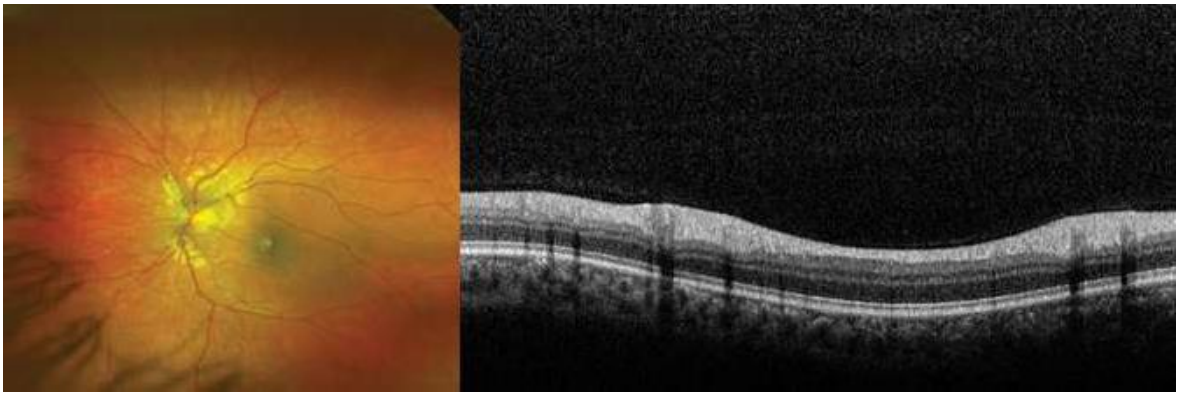
Light from very low-power lasers or a camera flash enters the eye through the pupil. Light reflected back leaves the same way to be collected by the machine creating an image of the retina. Similar typesof imaging are performed at a high street optician for a standard eye health check-up. However, we analyse these images in more detail to see what other information they could reveal about the health of human body and brain.

Retinal imaging takes a digital picture of the back of your eye. It shows the retina (where light andimages hit), the optic disk (a spot on the retina that holds the optic nerve, which sends information to the brain), and blood vessels. This helps your optometrist or ophthalmologist find certain diseases and check the health of your eyes.

Doctors have long used a tool called an ophthalmoscope to look at the back of your eye. Retinal imaging allows doctors to get a much wider digital view of the retina. It doesn't replace a regular eye exam, but adds another layer of precision to it.

The back of the eye is called the retina and is one of the few places in the human body allowing easy observation of blood vessels and nerves. These anatomical structures are shared with the brain, but where they are much less accessible. Subtle changes in the retina may reflect similar processes happening and these early signs may precede declining brain health by years or even decades.

Studying blood vessels in the eye is also useful in detecting and understanding diseases that affect the human circulatory system such as high blood pressure, diabetes and heart disease. For example, with further research, we may soon be able to identify people with undiagnosed high blood pressure through pictures of their retina, thus enabling a doctor to prescribe appropriate medication and considerably reduce their risk of having a future heart attack or stroke



Retinal images can be compared side-by-side over time to monitor your eye health and detect subtle changes. They allow your doctor to explain treatment more thoroughly as you can review the images

together, which ensures a certain level of precision to your routine eye exam.

Techniques

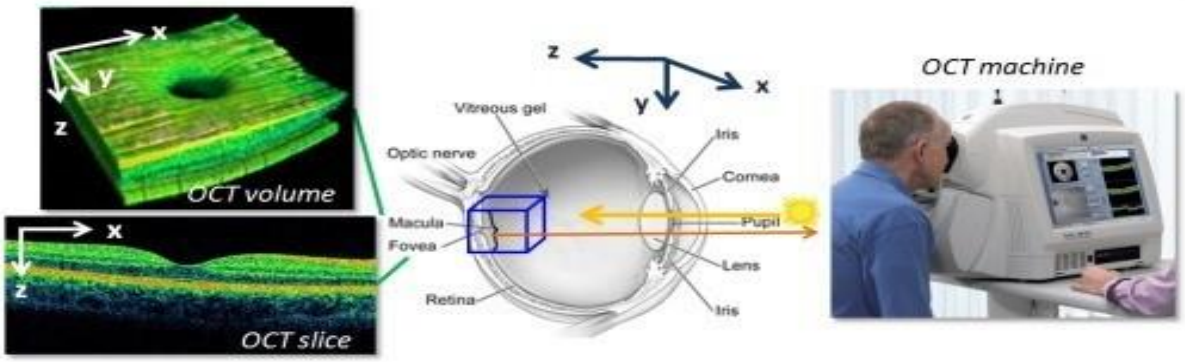
Retinal imaging has continuously improved through consistent research and development over theyears. There are a few different methods that your optometrist can use to inspect your eye.

- Optical Coherence Tomography
- Fundus Photography
- Angiography

Optical Coherence Tomography

- Optical coherence tomography (OCT) is a non-invasive imaging test. OCT uses light waves totake cross-section pictures of your retina.
- With OCT, ophthalmologist can see each of the retina's distinctive layers. This allows your
  ophthalmologist to map and measure their thickness. These measurements elp with diagnosis.

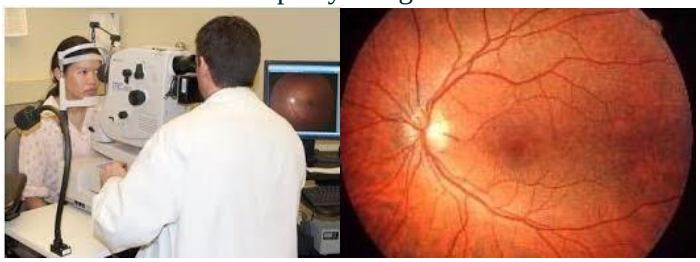
  They also provide treatment guidance for glaucoma and diseases of the retina. These retinal diseases include age-related macular degeneration (AMD) and diabetic eye disease.
- OCT is often used to evaluate disorders of the optic nerve as well. The OCT exam helps your ophthalmologist see changes to the fibers of the optic nerve. For example, it can detect changes caused by glaucoma.
- OCT relies on light waves. It cannot be used with conditions that interfere with light passing through the eye. These conditions include dense cataracts or significant bleeding in the vitreous.



Fundus Photography

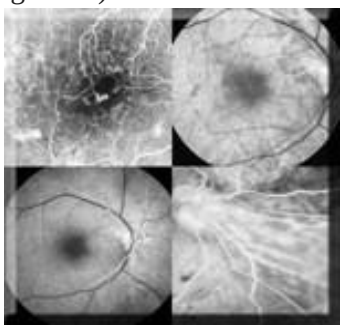
- The fundus is the back of the eye and includes the retina, optic nerve, and retinal blood vessels. In fundus photography, the fundus is photographed with special cameras through a dilated pupil, providing a colour picture of the back of the eye. The procedure is brief, only taking a minute ortwo, and painless.
- It's able to provide a picture of the retina, the retinal vasculature (blood vessels), and the optic nerve head, where retinal blood vessels enter the eye. It can also show drusen, abnormal bleeding, scar tissue, and areas of atrophy. In sum, it can provide your eye doctor with a visual picture of any abnormalities that may be present in the back of the eye.
- In terms of macular degeneration, fundus photography may reveal the extent of the disease

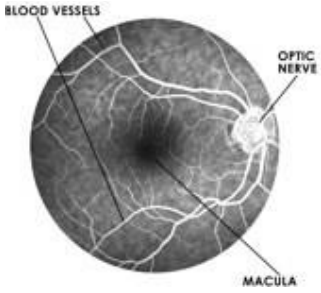
at that moment. This is especially important as the disease progresses – a series of fundus photographs can provide your doctor with a visual timeline of how it has affected your eye, as well as the severity and speed of the progression. Fundus photography is also used in other eye diseases, such as diabetic retinopathy and glaucoma.



Angiography

Fluorescein Angiography (FA) is a diagnostic procedure that uses a special camera to record the blood flow in the RETINA – the light sensitive tissue at the back of the eye. The test does not involveany direct contact with the eyes. Your eyes will be dilated before the procedure.Fluorescein dye is injected into a vein in the arm/hand. As dye passes through the blood vessels of your eye, photographsare taken to record the blood flow in your retina. The photographs can reveal abnormal blood vesselsor damage to the lining underneath the retina. The images will be captured in black and white. The dye will fluoresce in the blood vessels and be recorded as light grey or white in the image. Interpretation of the abnormal angiogram relies on the identification of areas that exhibit hypo fluorescence (darkness)or hyper fluorescence (brightness).





Who Needs Retinal Imaging?

Retinal imaging into an eye exam may be necessary if you have certain conditions.

- Diabetes can damage blood vessels in your eyes, which can cause loss of sight if not managed.
- Macular degeneration can occur with age, which causes sight to become blurry.
- Glaucoma damages the optic nerve due to fluid build-up in the eye and may cause vision loss.

Imaging application in Biometric systems

Images have a huge share in this era of information. In biometrics, image processing is required for identifying an individual whose biometric image is stored in the database previously. Faces, fingerprints, irises, etc., are image-based biometrics, which require image processing and pattern recognition techniques. For an image based biometric system to work accurately, it needs to have the sample image of user's biometric in a very clear and non-adulterated form.

Requirement of Image Processing in Biometrics

The image of user's biometric is fed into the biometric system. The system is programmed to manipulate the image using equations, and then store the results of the computation for each pixel. To selectively enhance certain fine features in the data and to remove certain noise, the digital data is subjected to various image processing operations. Image processing methods can be grouped intothree functional categories −

Image Restoration

Image restoration mainly includes −

- Reducing noise introduced in the image at the time of acquiring sample.
- Removing distortions appeared during enrolment of biometric.

Image smoothing reduces noise in the image. Smoothing is carried out by replacing each pixel by the average value with the neighbouring pixel. The biometric system uses various filtering algorithms and noise reduction techniques such as Median Filtering, Adaptive Filtering, Statistical Histogram, Wavelet Transforms, etc.

Image Enhancement

Image enhancement techniques improve the visibility of any portion or feature of the image and suppress the information in other parts. It is done only after restoration is completed. It includes brightening, sharpening, adjusting contrast, etc., so that the image is usable for further processing.

Feature Extraction

Two types of features are extracted from image, namely −

- **General features** − The features such as shape, texture, color, etc., which are used to describe content of the image.
- **Domain-specific features** − They are application dependent features such as face, iris, fingerprint, etcGabor filters are used to extract features.

When the features are extracted from the image, you need to choose a suitable classifier. The widely used classifier Nearest Neighbour classifier, which compares the feature vector of the candidate image with the vector of the image stored in the database.

B-Splines are approximations applied to describe curve patterns in fingerprint biometric systems. The coefficients of B-Splines are used as features. In case of iris recognition system, the images of iris are decomposed using Discrete Wavelet Transform (DWT) and the DWT coefficients are then used as features.