Ergonomics Research Techniques

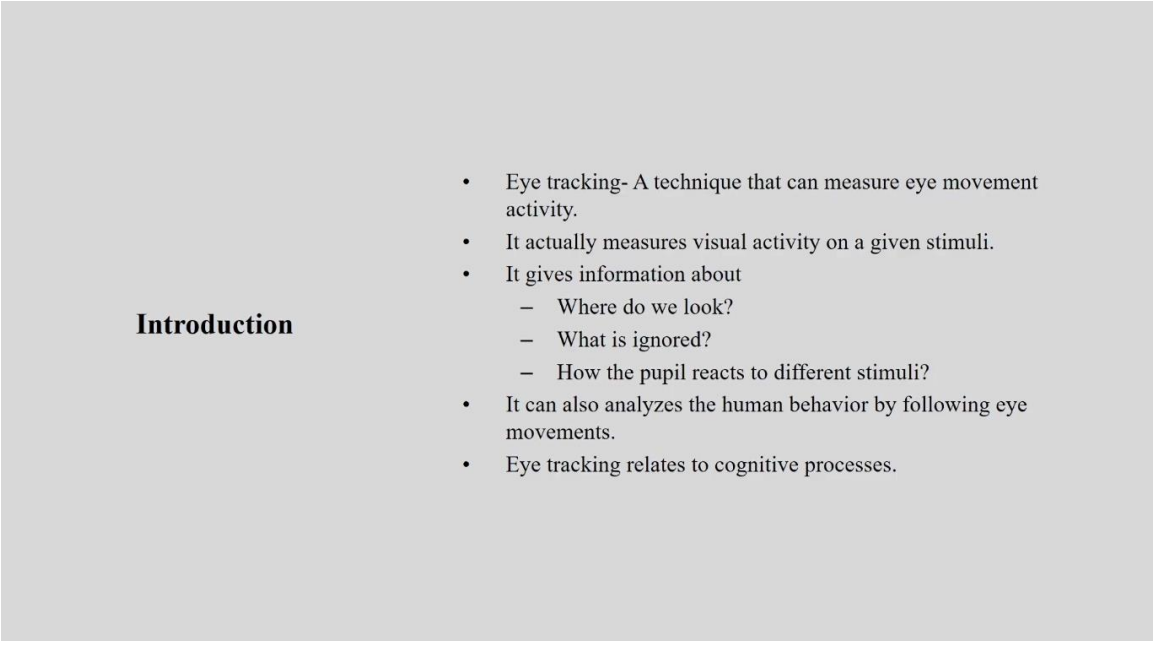
Dr. Urmi R Salve

Department of Design, Indian Institute of Technology Guwahati

Week 11: Lec 37- Mental workload measurement

Eye Tracking

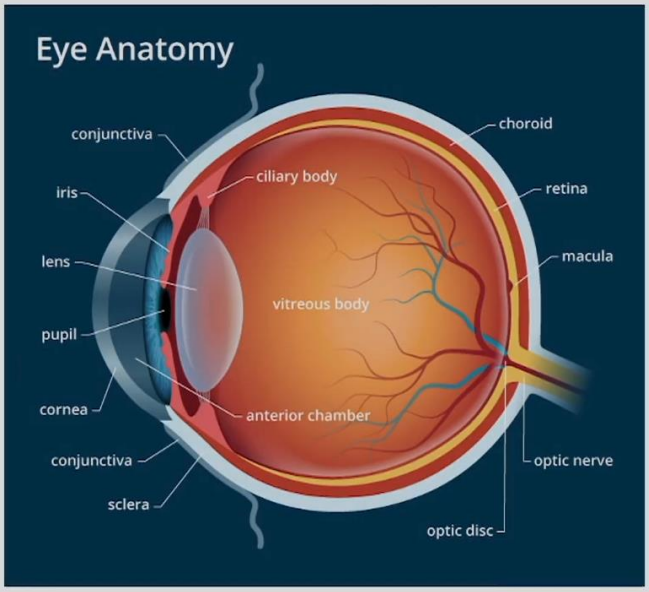
Welcome. Today we are going to discuss about the eye tracking system. So last classes we did about the electroencephalogram and epoch-emotive EEG. Now today we are going to understand it is a detailed study about the eye tracking. So when we are talking about cognitive ergonomics, behavioral understanding of a person in a particular working setup, this eye tracking system actually helps us to understand that in objectively. So this is a kind of instrument that we are going to use for tracking the eye movement and how we are going to understand the kind of movement we have in the eye and what is the connection between that with our cognitive behavior. So that we are going to discuss it today. This is very interesting topic and it is being extensively used in the cognitive science and cognitive ergonomics field and where we are talking about understanding the person, understanding the person's cognitive behaviour. So those case this particular technique or method is very fruitful and we use it very frequently. So, let us first know background of this particular topic and slowly we will go ahead with the technical aspect of this particular method.



So this is a technique that can measure the eye movement activities. So suppose I am looking at some object and how my eye is moving and how that is connected and how it

is giving an indication about the cognitive behaviour of that particular person or that particular movement. So, that we are going to understand through eye tracking system. So it actually measures the visual activity on a given stimuli. So if there is a stimulus, what is the impact of those stimuli on the visual activity? That we are trying to understand. So what exactly we are going to do? We are trying to understand where exactly the person is looking at, what is being not looked at. So suppose there is a screen, a person is looking at some direction or some particular object. Now what is being observed, what is being not observed? So what is being ignored? So that thing also we can understand and how pupil reacts to different stimuli. If there is a stimuli which is of red colour and of a particular size and if there is another colour which is maybe yellow or something else and the shape of the colour is you know object is different, then how they are you know how the pupil is reacting towards that differently. So these are the aspect that we are going to understand through this particular system. So it can also analyse the human behaviour by following the eye movement and eye tracking related to the cognitive processes. So how we are thinking, how we when we are looking at some object, what is the perception of that particular person about that particular object? So that perception, that cognition that we want to understand through this eye tracking system.

Anatomy of Human Eye

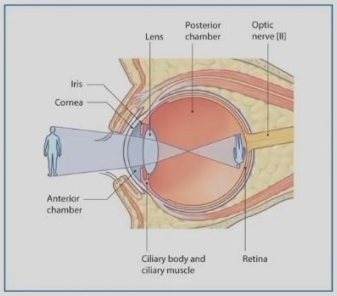


Before we go ahead, let us little bit understand the anatomy of the eye. So in this picture you can see what is the kind of structure we have in the eye. So it is not mandatory that you know all these nomenclatures properly, but yes if you want to study through eye tracking and you know the anatomy of the eye, it becomes very easy for you to understand the logic that why you are measuring what. So that is why this structure, this anatomy is important. So here you can see the major important part that is the lens is

situated here. This is the pupil and which is being either based on the concentration level, based on the visual acuity it is required, it gets constricted and it gets dilated. Also based on the impact of the environment, physical environment. So this is the cornea that we have and these are the sclera and here you can see this is the optic nerve, this is the optic disc, this is the retina where the images are going to form. So this is the basic structure of your eye.

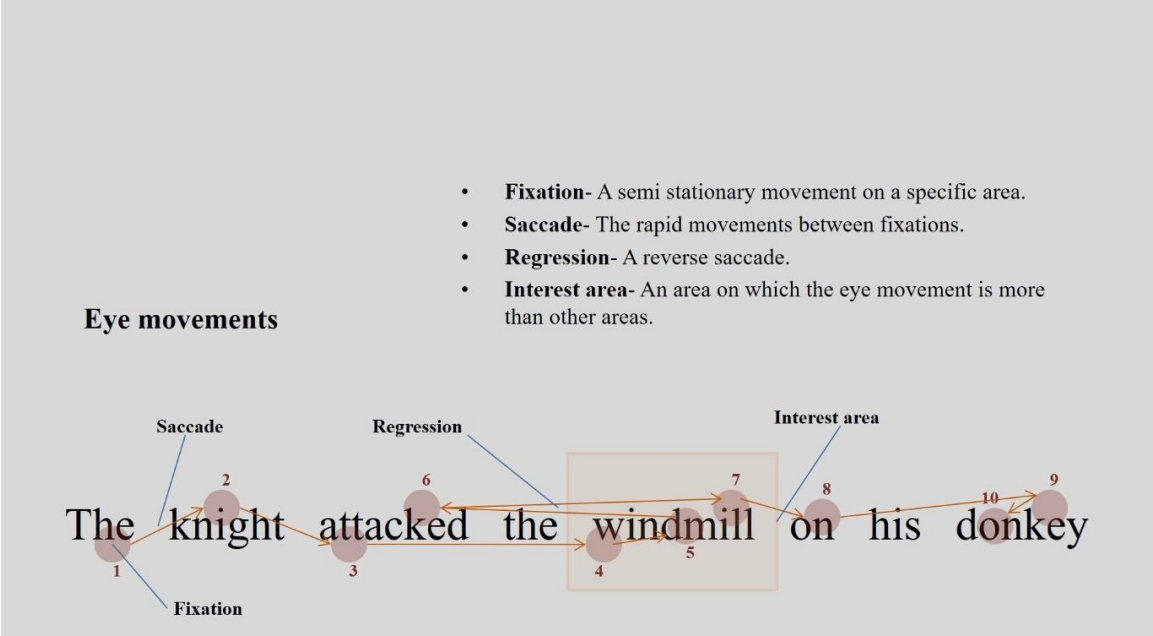
Anatomy of Human Eye

- **Pupil**- Controls the amount of light that can enter the eye.
- **Cornea**- Together with a sclera, forms a protective layer of an eye and two photoreceptors.
- **Retina**- The light sensitive layer of photoreceptors at the back of the eye. It receives image and sends them as electrical signals through the optic nerve to the brain.
- **Photoreceptors**- A type of cell which receives the light stimuli and interpret into neural stimuli to the brain
  - **Rods**- Responsible for peripheral vision and sensitive to objects movement.
  - **Cones**- Provide the central vision. Do well in bright light and discriminate colour.



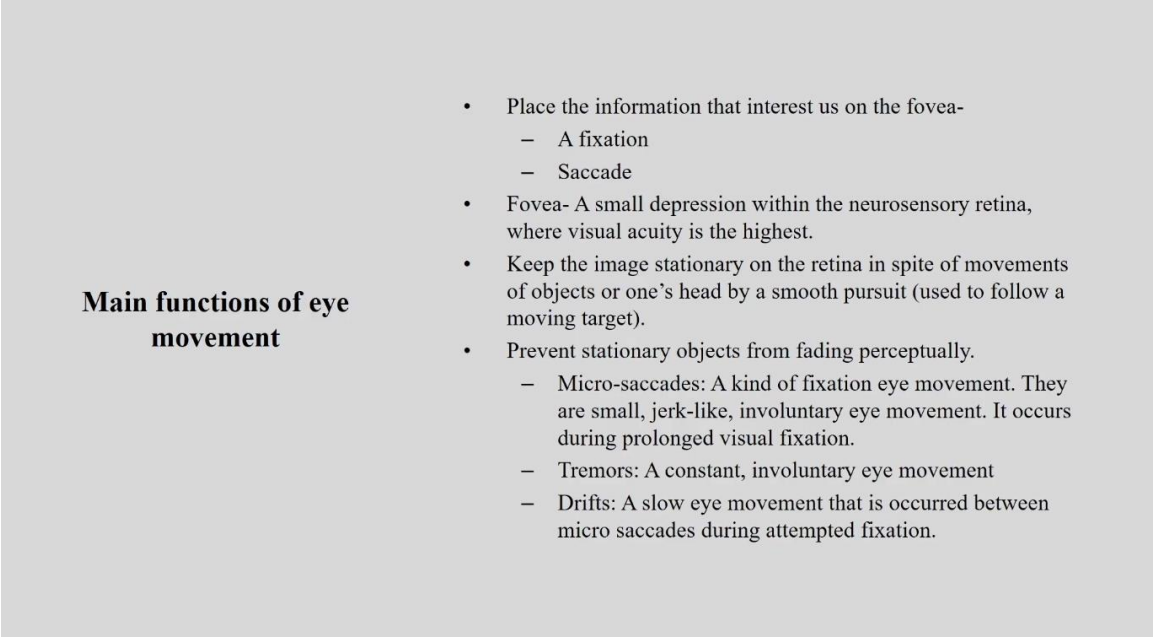
Now let us understand some important nomenclature or some important terminology which is going to help you in the eye tracking process. First one is pupil. So it actually what it does, it controls the amount of light that can enter in the eye. So pupil can get constricted or can get dilated. So it actually helps you to understand that what amount of light you are allowing to go inside your eye. So that is the pupil. Second is cornea. So together with sclera it forms a protective layer of an eye and two photoreceptors. Third is retina. So the light sensitive layer of photoreceptor at the back of the eye, it receives the images. Here the images actually forms and sends them through as electrical signal through the optic nerve of the brain. And final one is the photoreceptors. We have two types of photoreceptors, rod cells and cone cells. So rod cells are responsible for the peripheral vision and sensitive to the object's movement and cone cells which provides the central vision and do well in bright light and discriminate light. So these are the some important terminology we need to know before we go ahead with the eye tracking system. So when we are talking about eye tracking system, definitely we are going to give some kind of visual stimuli. So let us understand what are the broad classification of these stimuli. First one is the video clip, something is moving. Second one is the images, it is a static image. And third one is the static text. So these are the three major

visual stimuli that we are going to receive when we are talking about the eye tracking system or measurement through eye tracking instrument.



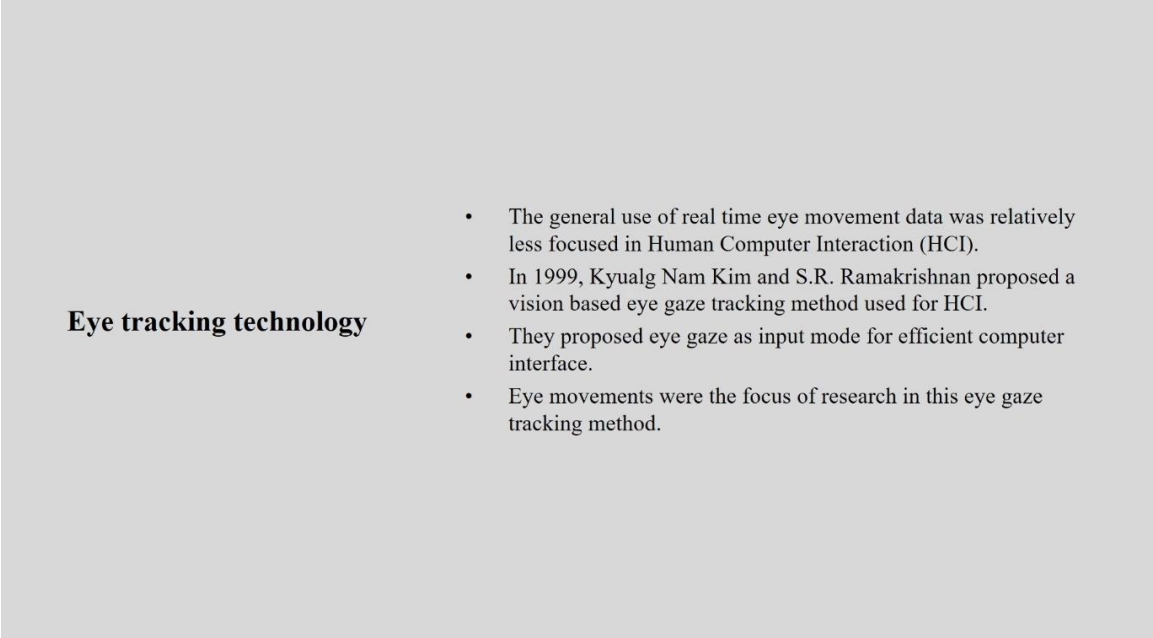
Now some important terminology that we are going to use throughout the eye tracking measurement system and these are the only thing that we are going to measure. So first one is fixation, second is saccade, third is regression and fourth is interest area. So first understand what is fixation. So fixation means a semi-stationary movement on a specific area. Suppose there is a sentence. Now I am going to read that sentence by reading single words. So what I am going to do, I will read the first word, then I will move to the second, then third, then fourth and likewise I will keep on moving. But whenever we are moving from one word to another word, there is a pause on each word. So that pause we call it as fixation. Now here in this particular example you can see the knight attacked the windmill on his donkey. Now see everywhere the knight attacked. So here when we are talking about maybe it is a long word, so why we are giving pause here and here. Then windmill, then on and this donkey, this is an example. So we are giving pause every certain interval in this particular sentence when we are reading it. So these semi-stationary movements we are going to call them as fixation. The second one is saccade. What is the rapid movement? So from one saccade to, sorry, one fixation to another fixation when we are moving that is called saccade. So there is one fixation here, another fixation here, another fixation here. So what I am, my eyes is doing? So my eye will move from one, then second, then third. So this movement we will be calling it as saccade. Then what is regression? Regression when we are going on the opposite direction. Suppose I read the sentence from left to right while reading I need some more clarification on my previous word. So what I am going to do? I am read back. My eye is moving to the previous word. So it is not from left to right, it is from right to left. So

if it is not in the same direction, it is just opposite direction in the saccade. So that is regression. Now fourth one is the interest area. An area on which the eye movement is more than any other area. So you are having saccade, you are having fixation, you are having saccade and you are reading it. But you can understand for a certain sentences or certain images that in some area your eye's fixations are more, your eye fixations are more as compared to any other area. So that is your area of interest. So it says that that particular area you are more interested to look into for some reason, we do not know. So that is the study that you need to conduct. So you can understand when there is a visual stimuli. Here it is a text stimuli in this particular example. You are reading the sentence from left to right and there is fixation in every word approximately and then what is happening there is a sequence of saccades. There is some kind of regression where you are moving back and looking at and understanding and going ahead and then there is some area what is area of interest. So you are having more fixation in that particular area. So these are four basic terms that you are going to use during your eye tracking system. Apart from that there are some more we are going to discuss it in next slides.

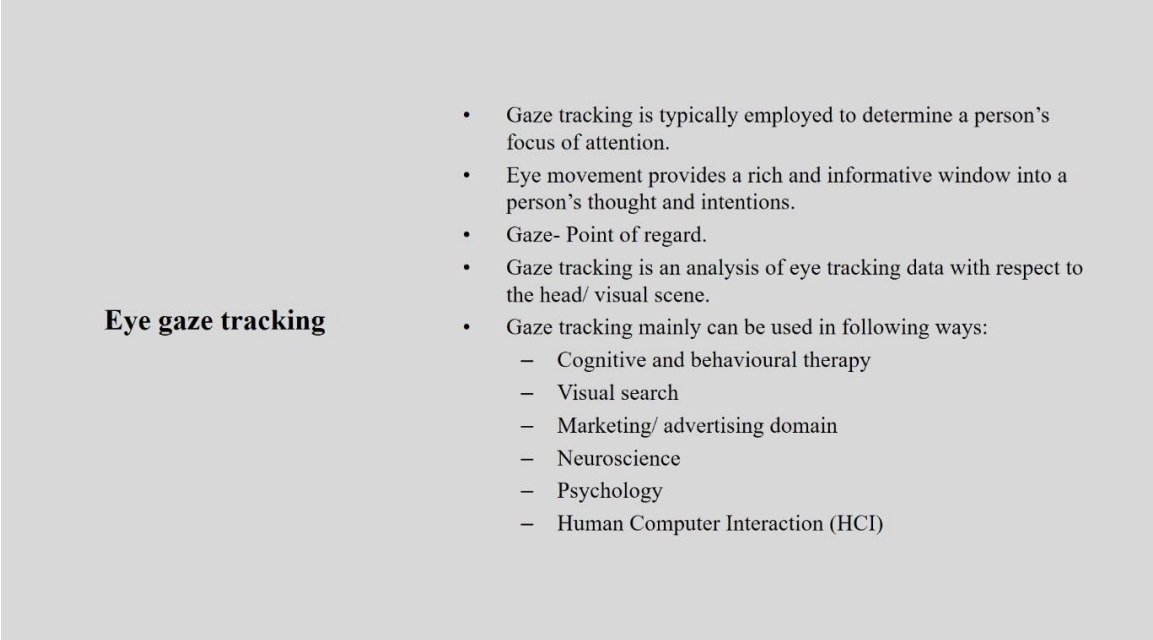


So what is the main functions of eye movement when we are talking about eye tracking system? So place of information that interest us on the fovea is the affixation and the saccade. So what is fovea? A small depression within the neurosensory retina where visual acuity is in the highest position and it keep the images stationary on the retina in spite of the movement of the object or one's head by a smooth pursuit. So movement then also it remains stationary. It also prevents the stationary object from fading perceptually. So microsaccades, tremor and drift. So let us understand what is microsaccade. So a kind of fixation of eye movement they are very small. It is a kind of jerk, involuntary eye movement. When it happens? When you have a long duration of

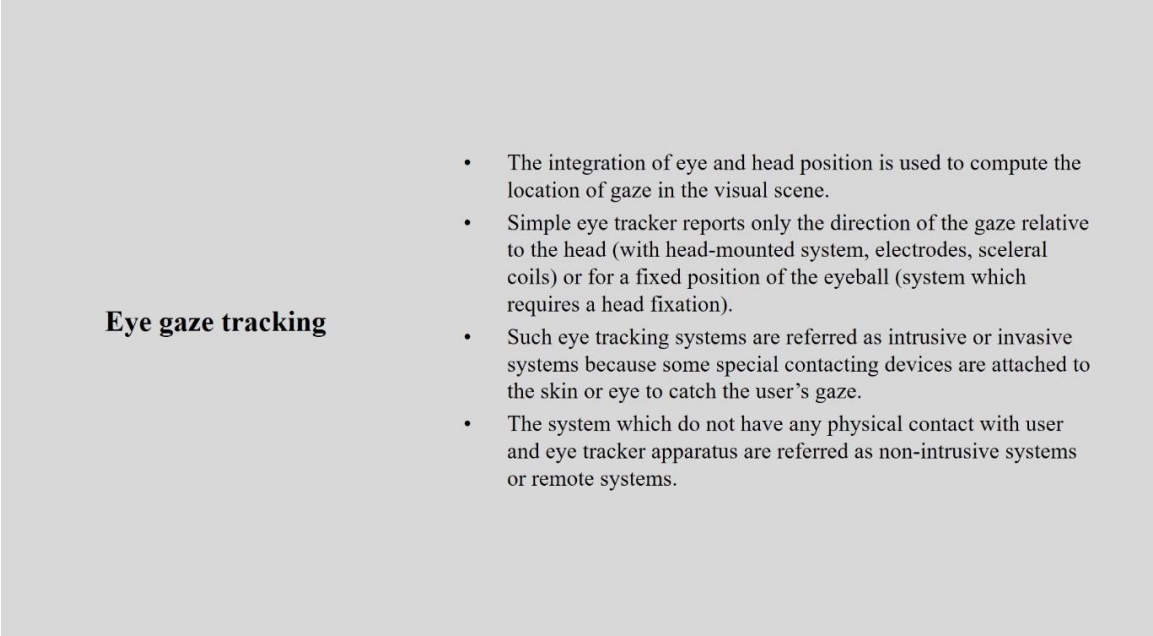
fixation, prolonged duration of fixation then there is small microsaccade. So no small sudden movement of your pupil. So that is microsaccade. So you are concentrating on a particular object. There is a fixation of a particular case for long duration. Still there is a little bit of jerking movement. So that is microsaccade. Now something is called as tremor. It is a constant and involuntary eye movement that is tremor and third one is the drift. A slow eye movement that is occurred between microsaccade during attempted fixation. You are trying to concentrate. So still there is small small microsaccades are there. So that is called, but it is very slow. So very slow eye movement that can occur between the microsaccades during the attempted fixation that is called drift. Now here we are going to measure all these things through eye tracking system and once we have all these details we are going to interpret that result according to our research objective.



So this particular technology that is called eye tracking system and the technology that is used for eye tracking system, the general use of this real time eye movement data was relatively less focused in human computer interaction. So in 1999 these two scientists Professor Kim and Professor Ramakrishnan proposed a vision based eye gaze tracking method which is used for the human computer interaction. They proposed eye gaze as input mode for efficient computer interface and eye movement where the focus of research in this eye gaze tracking method. So, from there this eye tracking technology is being derived.



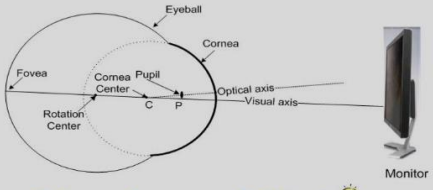
So, what is gaze tracking? Now we are talking about gaze. So, what is gaze tracking? Gaze tracking is typically employed to determine a person's focused attention. So, gaze means you are looking at an object with a concentration. So, focused attention. Eye movement provides a rich and informative window into a person's thought and the intention because suppose you are looking at something and then you are thinking about something, you are trying to interpret it. So, that can be connected with the gaze timing. So, gaze is the point of regard. So, you are trying to address it. So, gaze tracking is an analysis of eye tracking data with respect to head and visual sense. Gaze tracking mainly can be used in the following ways. First is cognitive and behavioral therapy, visual search, marketing and advertising domain, neuroscience, psychology, human computer interaction.



Little more about gaze tracking. So, the integration of eye and head position is used to compute the location of gaze in the visual scene. Suppose your neck is moving, your head is moving, eye is not moving, eyeball is not moving, eyeball is in a fixed condition, but if your head is moving, what is happening? Your gaze is changing. If you want to keep your gaze fixed when your neck is moving, so what you have to do? You have to change your eyeball direction, position. So, how these things are happening based on the visual stimuli? We are going to measure them using the eye tracking system. Now, you can understand one situation. Suppose you are in a moving bus and there is a signage on the roadside. Now, when we are moving, your bus is moving, you really need to move your neck, head and position of your eye to really read that information which is available. So, how you are fixing your gaze on that particular signboard by moving your neck, moving your head and moving your eyeball position. So, how these all studies can be done using this eye tracking system. So, simple eye tracker reports only the direction of the gaze relative to the head or for a position of the eyeball. Such eye tracking systems are referred as intrusive or invasive system because some special contacting devices, we will be describing that are attached to the skin or to the eye to catch the user's gaze. So, the system which do not have any physical contact with user and the eye tracker apparatus referred as non-intrusive system or remote system. So, we have something which is connected to the skin and to the eyeball. So, they are the intrusive system whereas, some are can be operated remotely, ok. We will be discussing them as well.

Eye gaze tracking

- Eye tracker basically captures eye movement by using light source that illuminates eye that causes visible reflection.
- It uses a high resolution camera to capture eye image to show these reflections.
- Then this eye image is used to identify the reflections of the light source on the cornea and pupil.
- Then vector formed by angle between the cornea and pupil reflections is calculated.
- Based on this information the gaze direction is calculated.
- The vector calculation methods include:
  - Velocity based
  - Dispersion based
  - Area of interest



We know where are you looking at

So, when we are talking about eye gaze tracking, we need to understand how this whole system actually works. So, eye tracker basically captures the eye movement, how this eye movement by using the light source that illuminate the eye causes visual reflection, ok. So, there is a light which is going to reflect through the eye and which is being captured by the system and they are going to understand what is the eye movement is happening. So, it uses a high resolution camera to capture eye image to show these reflection. Then, this eye images is used to, so first is capturing and then they are going to process it. So, these eye images is used to identify the reflection of the light source on the cornea and the pupil. Then vector formed by an angle between the cornea and pupil reflection is calculated. Based on the information, the gaze direction is calculated and the vector calculation method include the velocity, what is the velocity, maybe it is related to velocity based or depression based or based on the area of interest, ok. So, we can see how these things can be done. So, if this is the system, we can understand how things are being processed. So, visual axis, how in the fovea, how the images are being formed and if you can capture your whole eye movement, you can understand what is the fixation, what is the eye tracking or ranges or duration and then we can interpret what is the level of concentration, interest area and so on, ok.

Eye gaze tracking

- **Eye tracker type**
- The following two types of eye trackers are available in market:

Remote/ screen based eye tracker

Head mounted eye tracker

More about gaze tracking. So, we can have different types. One is remote or screen based eye tracker and second is head mounted eye tracker. Two major type, one is remote and screen based eye tracker and second one is the head mounted eye tracker.

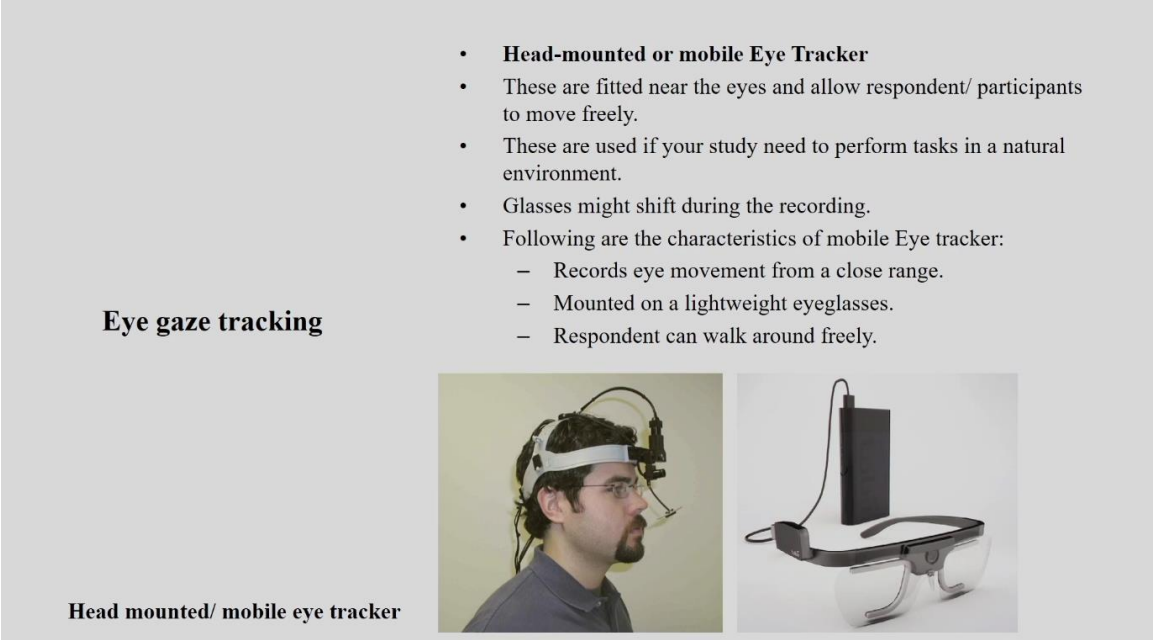
Eye gaze tracking

- **Remote/ screen based eye tracker**
- This type of eye tracker requires the respondents/ participants to sit in front of a screen to interact with the stimuli or screen based content.
- Remote ET system track the eyes within certain limits called headbox, but the eye movement freedom is sufficiently large and the respondents feel unrestricted .
- Following are the characteristics of remote eye tracker:
  - Records eye movement at a distance.
  - There are no attachments to the respondents.
  - Computer or screen mounted.
  - Respondents sits in front of ET.
  - Observations on any screen-based stimulus materials, offline stimuli can be recorded.

Remote/ screen based eye tracker

So, first understand, first one that is the remote or screen based eye tracker. So, this type of tracker requires the respondents or participant to sit in front of a screen because it is a screen based to interact with the stimuli or the screen based content. Remote eye tracking system track the eyes within certain limits called head box, but the eye movement freedom is sufficiently large and respondents feel unrestricted, ok. Following are the

characteristics of the remote eye tracker. It records the eye movement at a distance. There is no attachment to the respondents, ok. There is no attachment. So, respondent is freely sitting in front of a screen. Computer and screen is needed to be mounted. Participants sit in front of the eye tracking system. Observations on any screen based stimulus or stimuli material or offline stimuli also can be recorded, ok. So, that is the remote or screen based eye tracking system.



The second one which is very frequently used system that is the head mounted or mobile eye tracker. So, these are fitted like you know as we had some kind of headgear in EEG, here also we will have some kind of headgear. So, these are fitted near the eyes and allow the respondent or participant to move freely. These are used in your in any of the study need to perform the task in a natural environment. So, you are not fixed in the computer screen. You can do whatever you want to do because you are free to move, ok. So, you are going to this rack, you are going to that rack, you are doing your own activities, ok. You are not restricted to move, ok. So, that is the beauty of this particular system. And what it exactly this mobile eye tracker does? It records the eye movement from a close range. Of course, you cannot go beyond the range, so that near data recording is not possible. Mounted on a lightweight eyeglass, you can you need to wear an eyeglass and respondent can walk around freely. So, these are the things are possible for the mobile or head mounted eye tracking system.

Eye gaze tracking

- The eye trackers are available in the market from following organizations:
  - Tobii
  - SMIVision
  - EyeLink
  - Interactive Minds
  - Imotions
  - Mirametrics
  - EyeTech

Tobii

SMIVision

EyeLink

EyeTech

Mirametrics

So, the eye trackers whatever is currently available in the market, these are some very frequently used system, you can have some more, but I have noted which are normally being used in different research laboratory. Very common one is Tobii, then SMI vision, eye link, interactive minds, emotions, you know, all these system whatever I have mentioned over here, these are available. There may be some more, but these are something very commonly available in any of the research laboratory.

Eye tracker metrics

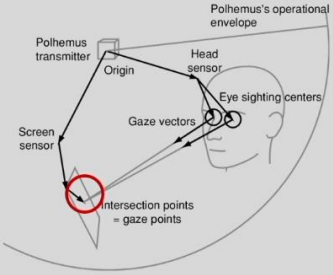
- Following metrics from an eye tracker and the information can be analyzed for various applications:

Gaze points	Fixation	Smooth pursuit
Saccades	Scan paths	Heat maps
Area of interest	Fixation sequence	Respondent count
	Time spent	

So, when we are talking about eye tracking, we let us understand what are the varieties of matrices we are going to get from the eye tracking system. First is gaze point, we will be discussing each one separately. So, first understand what are the varieties available.

Eye tracker metrics

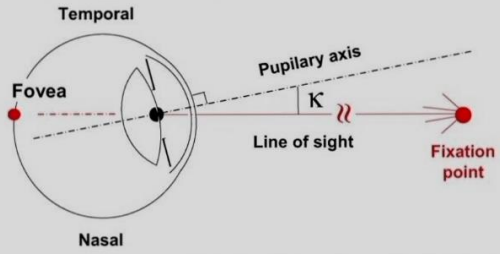
- **Fixation and gaze points**
- The main metrics used in eye tracking are fixations and gaze points
  - **Gaze points**
  - The basic units of measuring the eye movements are gaze points.
  - Each gaze point is an individual record of the participant's gaze at a given moment.
  - The number of this individual moments per second depends on the sampling rate of ET device.
  - One gaze point is one row captured by the ET device.



First is gaze point, second is fixation, then smooth pursuit, then saccade, scan path, hit map, area of interest, fixation sequence, respondent count and time spent. These are all n types of variables that we are going to get through the eye tracking system. Now, for each study, you may not need all these 10 variables to be interpreted. Based on your objective, you need to decide which are the variable are important for you and which you can do the analysis. You will get the recording, but you may not need to know analyze everything for every study. Based on your objective, you can choose any one of these variables or combination of 2 and 3. Now, let us understand each variable separately. First one is fixation and gaze point. So, the main metrics used in eye tracking are the fixation and gaze. So, what is gaze point? The basic units of measuring the eye movement are the gaze point. Each gaze point is an individual record of participants gaze at a given moment. At a particular moment, what is the gaze the participant has? So the number of individual moments per second depend on the sampling rate of the eye tracking system. So, systems or system like Tobii, SMI, every system has their own speed, own data sampling rate. So, based on that you can have different category. So, one gaze point is one row captured by the eye tracking device in a particular case. So, that is the gaze point. Now fixation, a fixation is a cluster. So, you understand gaze, right? It is just a point.

Eye tracker metrics

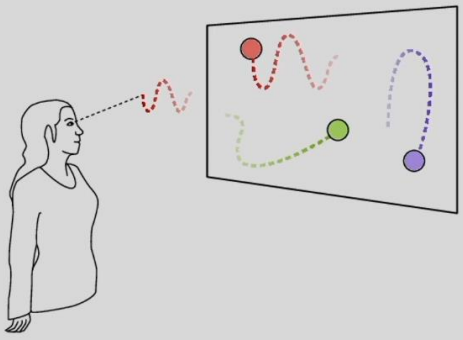
- **Fixation and gaze points**
- The main metrics used in eye tracking are fixations and gaze points
  - **Fixation**
  - A fixation is a cluster denoted by a series of gaze points which are to be close in time and range.
  - Fixation is a period in which our eyes are fixed at a particular object in a stimulus.
  - Typically fixation duration is 100 – 300 millisecond.



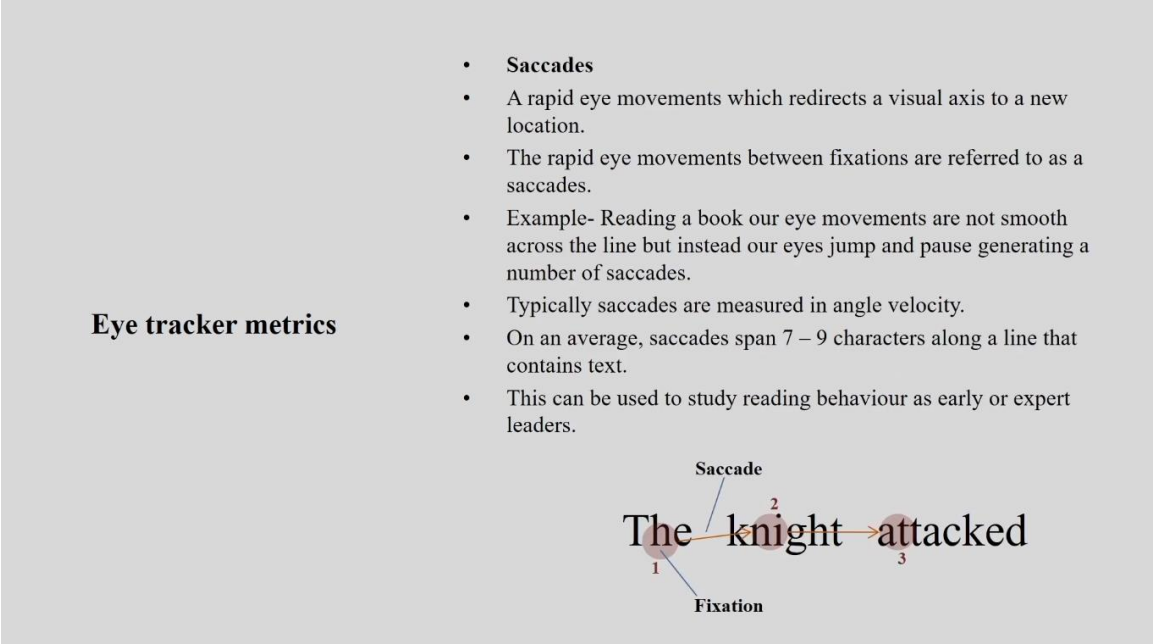
Now, next is your fixation. So fixation is a cluster denoted by a series of gaze point which are to be close in time and range. So, you have a gaze point here that is first gaze, okay. Second, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, tenth, eleventh, twelfth, thirteenth, fourteenth, okay. So now this becomes your fixation, right? So, gaze is a point and if you have some gaze at a very closed range and time, then that is the fixation, okay. Fixation is a period which our eyes are fixed at a particular object in a stimuli. So typically fixation durations are 100 to 300 milliseconds, okay.

Eye tracker metrics

- **Smooth pursuit**
- It is an eye movement that allows eyes to closely follow a moving object, i.e., voluntarily shift gaze.
- Example- imagine watching clouds in the sky.
- Here our eye movements are quite opposite as our eyes follow moving object steadily (clouds)



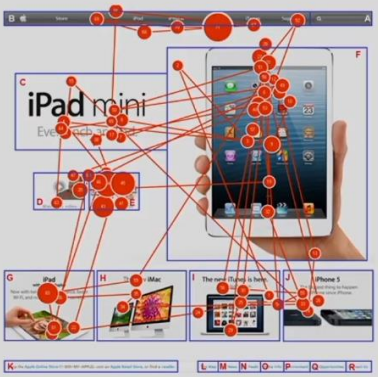
Now smooth pursuit. What exactly it means? There is a movement and which is very smooth. There is no jerk, okay. You can see here it is a very smooth movement, very smooth movement. So that is the smooth pursuit. Exactly how we are going to explain it? It is an eye movement that allows the eye to closely follow the moving object and it is a voluntarily shift gaze. So you are voluntarily doing it. It is not that you are forced to do it. You are doing it voluntarily. Example when you are trying to follow a cloud movement. Cloud is moving, your gaze is also moving. You are following the cloud, but it is a very smooth movement, right? So that is the smooth pursuit. So when there is something is happening in a particular moving object, how your eyes is moving, okay? So that is your smooth pursuit.



Next is saccade. So a rapid eye movement. So smooth pursuit is not saccad, okay? So a rapid eye movement which redirects a visual axis to a new location. There is one gaze, there is another. So you are moving from here to here. So you are viewing axis, optical axis. From here you are moving here. So it is moving redirecting to another point, okay? So visual axis to another new point that is the saccad. So rapid eye movement between fixation are referred to as saccad. So reading a book, when you are reading a book, the eye movements are not really smooth across the line, but instead our eyes jump and pause generating the number of saccad. So typically saccads are measured in angle velocity. On an average saccad span 7 to 9 characters along a line that contains the text, okay? This can be used to study the reading behavior as early or expert reader. So somebody is reading, so you know kids when they are reading, they go slow, slow, one word, second word, third word, like that. But when we adult we read, we read very fast, right? Or maybe all adults not read on a specific speed, okay? Everyone has their own pattern of reading. So those things can be studied using the saccad.

Eye tracker metrics

- **Scanpath**
- It was first defined by David Noton and Lawrence Stark in 1971.
- The sequence of fixation-saccade-fixation is referred to as scanpath.
- It is an ordered set of fixations points (depicted by circle) connected by saccades (depicted by lines).

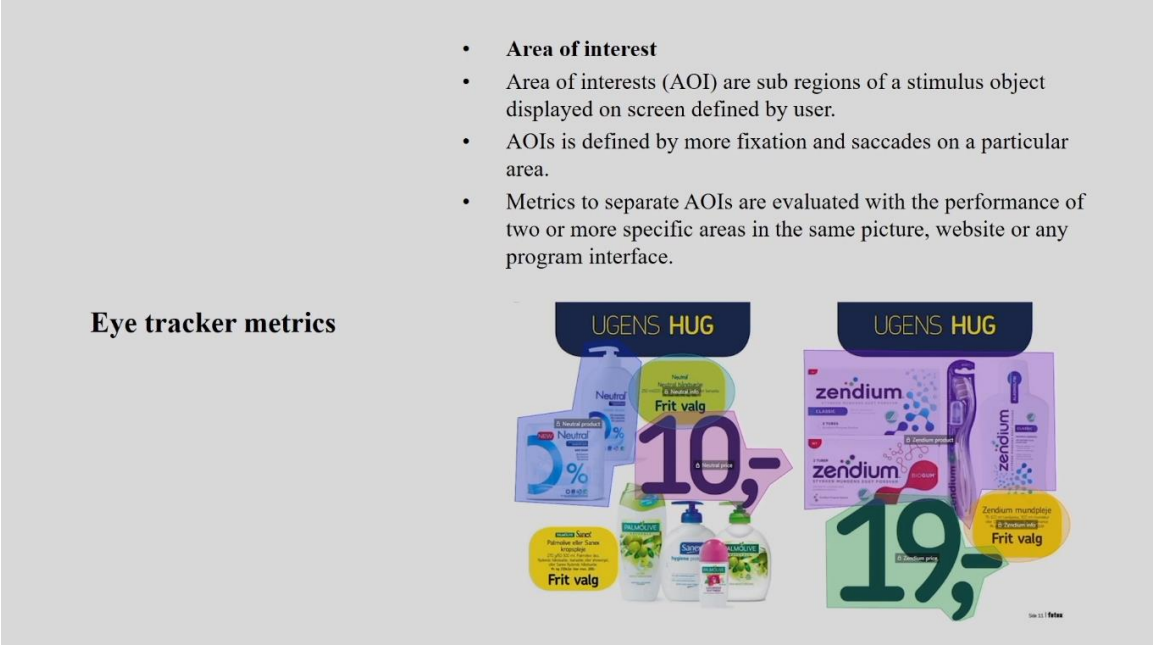


Next one is scan path. Name itself shows how my eyes are scanning the whole thing and how I am drawing that particular path. So that is scan path. So this particular thing is being described and defined by Devin and Lawrence in 1971 and the sequence of fixation, saccad and fixation is referred as this scan path. So there is a fixation, there is a saccad and then again it is a fixation. So I am going to here, here, here, here, here, so I am moving around. So I am following the path of my fixation. So that is called scan path.

Eye tracker metrics

- **Heat maps**
- The static or dynamic or static aggregations of gaze points and fixations generate the distribution of visual attention are presented through the heat map.
- Heat maps serve as an excellent method for visualization; it shows maximum attention area of the stimulus.
- Heat maps use easy to read colour coded scheme.
- A high number of gaze points are indicated by Red area and show an increased level of interest.
- Yellow and green area point toward less visual attention.

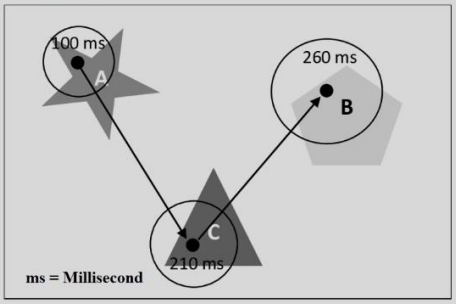
Heat map. This is very commonly used visualization tool when we are talking about the eye tracking system. It is a color coded representation that what is our area of interest, what is our gaze point where we are looking at for long duration. So everything is being color coded and we can understand from those color that how my eyes are moving. So this particular static or dynamic or static aggression of gaze points and the fixation generate the distribution of visual attention. So distribution of visual attention we can represent it through the heat map. So heat map serves as an excellent method for the visualization as I mentioned earlier. It actually shows the maximum attention area of stimulus. So heat map used easy to read color coded scheme. If it is red that means you have highest amount of concentration and yellow and green shows less amount of concentration as compared to red area. So that is giving you a direction that which component is taking more attention from the viewer. So using heat map you can have very nice visualization that how your attention is distributed in the whole screen or in the visual platform.



Now area of interest we already discussed this one a little bit. So area of interest are the sub regions of the stimulus object displayed on a screen defined by the user. So area of interest are defined by more fixation and saccades on a particular area and matrix to separate area of interest are evaluated with the performance of two or more specific areas in the same picture, website or any program interface. So that way we use area of interest and we redesign the things properly.

Eye tracker metrics

- **Fixation sequence**
- It can be generated based on fixation position and time information.
- It depends on where a respondent looks and for how long.
- We can build an order of attention where the respondent looked first, second and so on.
- This parameter is used in research as it reflects salient elements in the display or in an environment that catch much attention.
- AOIs that respondents look at first are visually more salient and hence are of more interest.



Next is fixation sequence. Again from name you can understand what is the meaning of fixation sequence. So it can be generated based on the fixation position and the time information. So the sequence- first this is my fixation point then this, then this, then this, maybe again coming back here. So 1, 2, 3, 4 and again 5. So this is the kind of sequence I have. So it depends on where a respondent looks and for how long. We can build an order of attention where the respondent looked first and then second and so on. So this particular parameter is used in research as it reflects the salient element in the display or in an environment that can catch much attention. So suppose we are designing some web page, which component need to be put where and how it is going to attract or is going to create the visual attention for the viewer. So these are the things to be taken care when we are talking about fixation sequence. So area of interest that response look at first are visually more salient and hence are the more interesting area. So these are connected. So what is the kind of statistics we can play here? Lot of correlation, then association, all those things we can do and we can have very nice analytical research through these type of variables.

Eye tracker metrics

- **Respondent count**
- This metric allows to extract more information about the number of respondents had gaze direction towards a specific AOIs.
- Higher respondents count indicate that fixations and gaze points are driven by some external aspects in the stimulus.

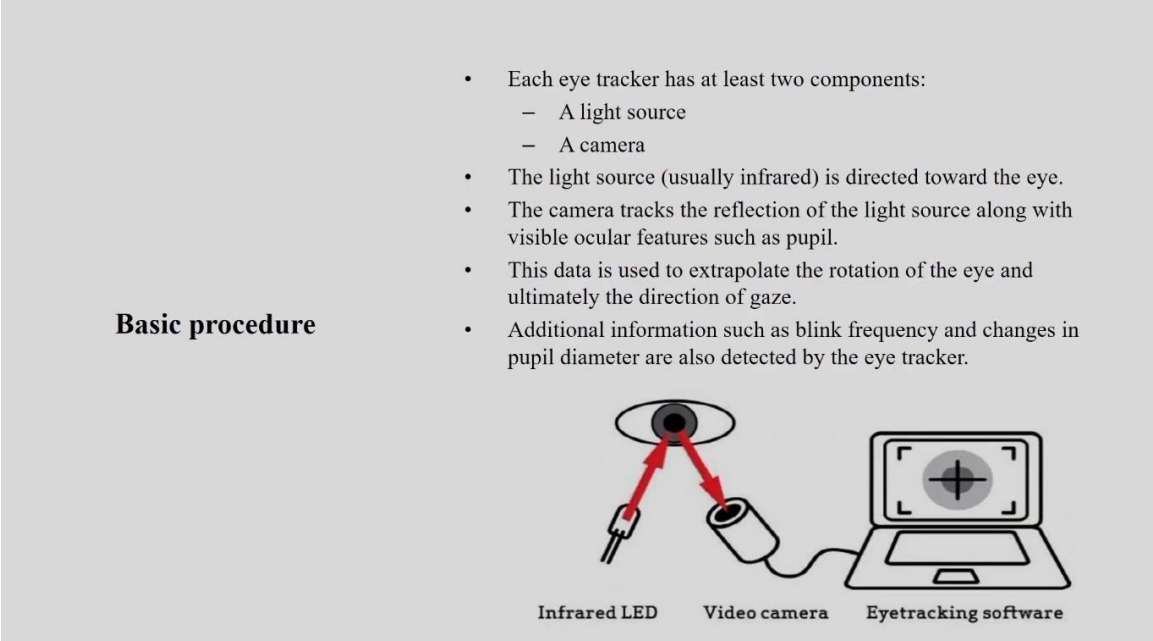
Now respondent count. This particular metric allows to extract more information about the number of respondent at gaze direction towards a specific area of interest. Higher respondent count indicate that fixation and gaze points are driven by some external aspect in the stimuli. So through this we can understand the respondent count and using that we can understand what are the external stimuli are there and how the external stimuli is going to affect your visual attention.

Eye tracker metrics

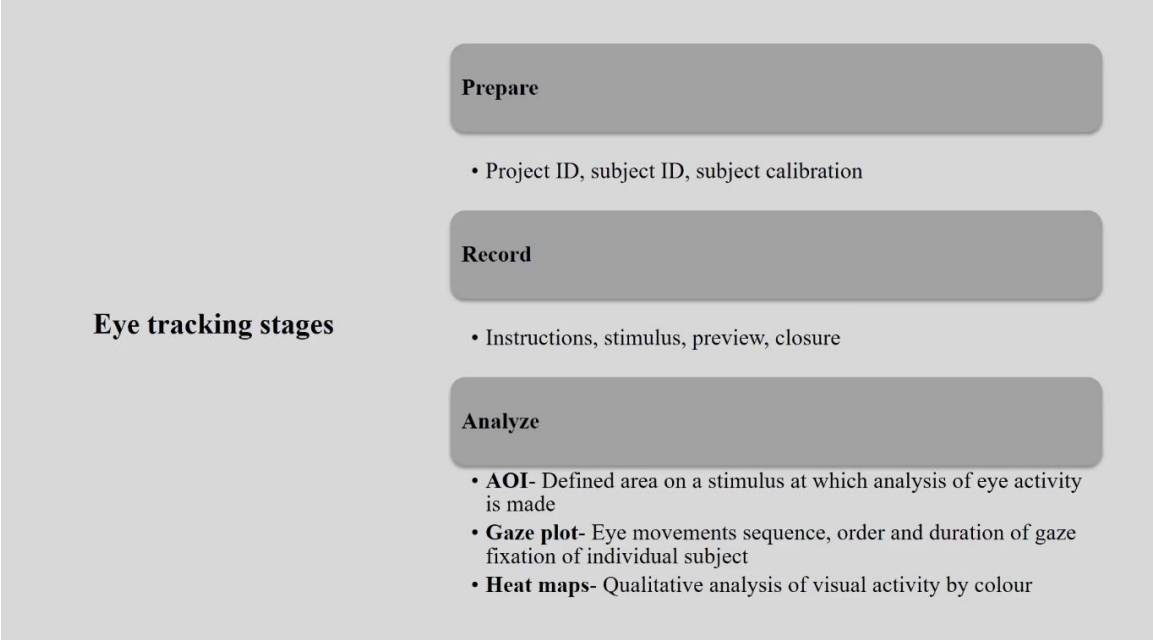
- **Time spent**
- Time spent specifies the amount of time that respondents have spent on a specific AOI.
- It often indicates motivation and conscious attention because long prevalence at a region to a high level interest.

Time spent. The time spent specifies the amount of time that respondents have spent on a specific area of interest and it is often indicates motivation and conscious attention

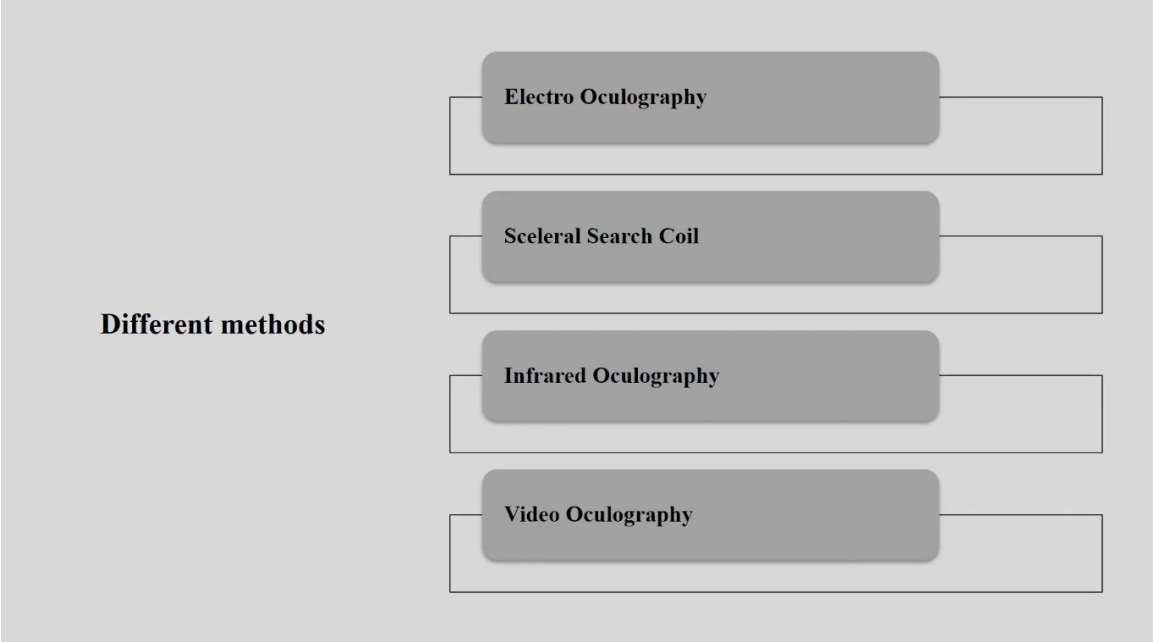
because long prevalence at a region to a high level of interest. So this is also a very important variable and this particular variable can be correlated or associated with many other previous variables and you can have very interesting results coming out from your data whichever you are going to collect.



Now let us discuss little bit about the basic procedure that we are going to follow. So we need a light source and we need a camera. Each eye tracking system should have these two basic things. The light source usually it is infrared is directed towards the eye and the camera which is going to track the reflection of the light source along with the visible ocular features such as pupil. This data is used to extrapolate the rotation of the eye and ultimately the direction of gaze. So additional information such as blink frequency, changes in the pupil diameter these are also can be detected by the eye tracking system. So eye trackers collect raw eye movement data points every 16.6 or 8.3 milliseconds depending whether the sampling data range is 60 Hz or 120 Hz and each data point will be identified by the time stamp or and the x-y coordinate and spent to the analysis application database running to the computer connected to the eye tracking system. So in order to visualize the data, these coordinates will then be processed further into fixation and overlaid on a video recording of the stimuli used in the rest.



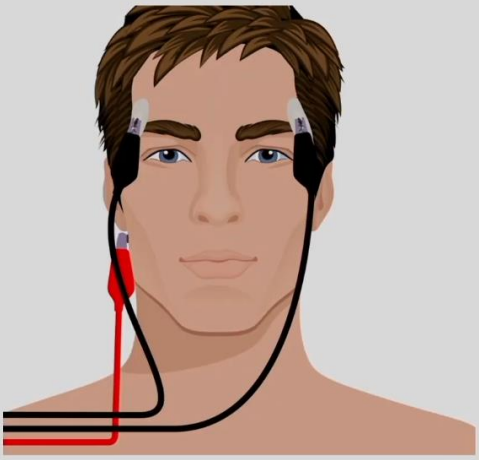
So how do we prepare? So we have to create the ID for and you need to do the calibration first. That is the first requirement. Second is you have to do the recording that is the instruction stimulus and preview and you need to conduct the experiment and close it. Then how do you analyze it? AOI, Gaze plot, heat map all these things you can analyze. For AOI, you have to define the area of stimulus at which analysis of the eye activity is being made. For Gaze plot, so these are the things you are going to get from the system. Eye movement sequence, order and duration of gaze fixation of the individual subject. Heat map is very important it is a qualitative data, so qualitative analysis of the visual activity by color. So red means highest amount of attention, yellow is lesser than red and green is the least amount of attention in a particular visual field. Okay.



So different methods are available. We are going to give very brief description of it and then based on the availability of the system whatever you have you can choose any one of them and whatever we discussed about the variables that you can use for your results and your interpretation and your objective validation. The first one is the electro oculography, second is scleral search coil, then infrared oculography and video oculography. So these are the four basic types you can have any one of them and based you know you can use them as per your requirement. So these are the things we are going to learn today. So I will give very brief description we have very short duration of time we may not be able to describe each in detail however I am going to tell you the basic of each system separately.

Electro Oculography

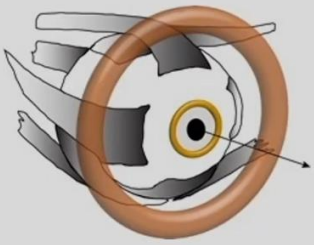
- In this method, sensors are attached at the skin around the eyes to measure an electric field exists when eyes rotate.
- By recording small differences in the skin potential around the eye, the position of the eye can be estimated.



So what is electro oculography? So electro that means you are going to understand the electrical responses right. So in this particular method the sensors are attached to the skin around the eyes to measure an electrical field exist when your eye is rotating. Okay so by recording small differences in the skin potential around the eye the position of the eye can be estimated. So this is just a brief description. Now if you want to know this particular system in detail you have to do it by yourself. This is out of the scope right now because it needs lot of time okay.

Sceleral Search Coil

- When a coil of wire moves in a magnetic field, the field induces a voltage in the coil.
- If the coil is attached to the eye, then a signal of eye position will be produced.
- In order to measure human eye movement, small coils of wire are embedded in a modified contact lens.
- This is inserted into the eye after local anaesthetics has been introduced.
- An integrated mirror in the contact lens allows measuring reflected light.



Next is scleral search coil. So here from the name again you can understand it is a you are going to insert the coil and we are going to understand or monitor the eyeball movement. So when a coil of wire moves in a magnetic field the field induces a voltage in a coil and if the coil is attached to the eye then a signal of eye position can be recorded and if it is being produced it that can be recorded. So in order to measure the human eye movement, a very small coil of wire are embedded in a modified contact lens. So you are inserting so it is a in vivo right. So this is inserted into the eye after a local anesthesia is being introduced. So an integrated mirror in the contact lens allows the measuring reflected eye. Like this type of technique need to be taken care with a proper facility and with lot of expertise okay. So who are very much capable enough to handle such instrument they only should do this. Because here we are talking about local anesthesia and we are talking about inserting that particular modified lens in the eye and then the capturing the data. So it is not very easy so if you are doing it, do with a proper supervision of the experts and with a proper training. Without that we should not try this out.

Infrared Oculography

- It measures intensity of reflected light.
- In this method, the eye is illuminated by infrared light which is reflected by the sclera.
- The light source and sensors can be placed on spherical glasses.

Third one is infrared oculography. This is very commonly used and mostly in laboratories we have this type of facilities. So it measures the intensity of the reflected eye, reflected light and in this method the eye is illuminated by the infrared light which is reflected by the sclera and the light source and the sensors can be placed on a spherical glasses. So it is a kind of eye glass and you have a camera in position different based on the company. You have the position of the camera and then you can measure them okay. So this is the infrared occulography.

Video Oculography

- It is most widely used eye tracking method in commercial eye trackers.
- It uses single or multiple cameras to determine the movement of eye using the information obtained form the images captured.

And the last one is the video oculography. So what it does? It is the most widely used eye tracking method in commercial eye tracker and it uses single or multiple cameras to determine the movement of the eye using the information obtained from the image captured okay. So from there they do the video recording of your eye and it gives it analyze the data in background and it gives the results about the fixation, it gives the results about the circles, eye scan path and everything okay. That is all the varieties of techniques available for the eye tracking. There are many more things to be discussed as when we are talking about eye tracking. However, we have limited scope. So what I suggest everyone whatever is available with you so you, try the data you try how to handle the instrument, how to collect data and how to analyze the data that is very important. So based on your objective which variable to be selected for your interpretation. So those things you should practice and if you have any specific research project which is intended to use the eye tracking system then you can try it out and if you have any doubt in the analysis part or data collection part or understanding of any one of the variable you can write back or call or email me for further discussion. So that is all for eye tracking system and we will proceed with some more measurement of the cognitive behavior like HEART and CREAM in next classes. Thank you. .