Path Retracing Using Augmented Reality

Aayush Chauhan (20168048)
Ayush Gupta (20168024)
Surbhit Awasthi (20169008)

Content

Problem Description

- Retracing path, without using GPS technology, and without internet.
- An application which can assist in local mapping.
- Use Cases:
    - Internal Building Mapping
    - Cave Exploration
    - Rescue Operation

1. Augmented Reality Definition

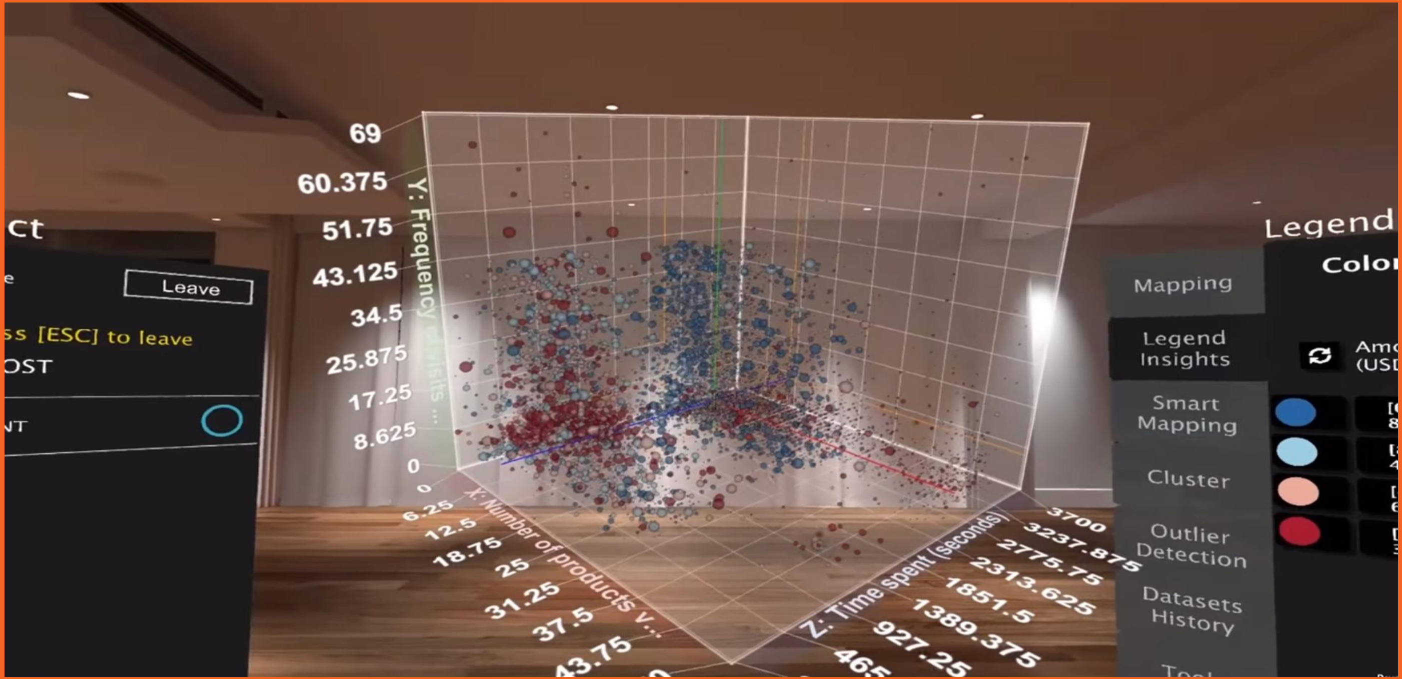
- **Augmented reality** (**AR**) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated virtual objects.
- Essentially it's putting **virtual object** and placing them **in real world**.
- Augmentation is conventionally in real-time and in semantic context with the environmental elements For example - sports score during a live cricket match

Characteristics of AR systems

Combines real and virtual objects in real environment

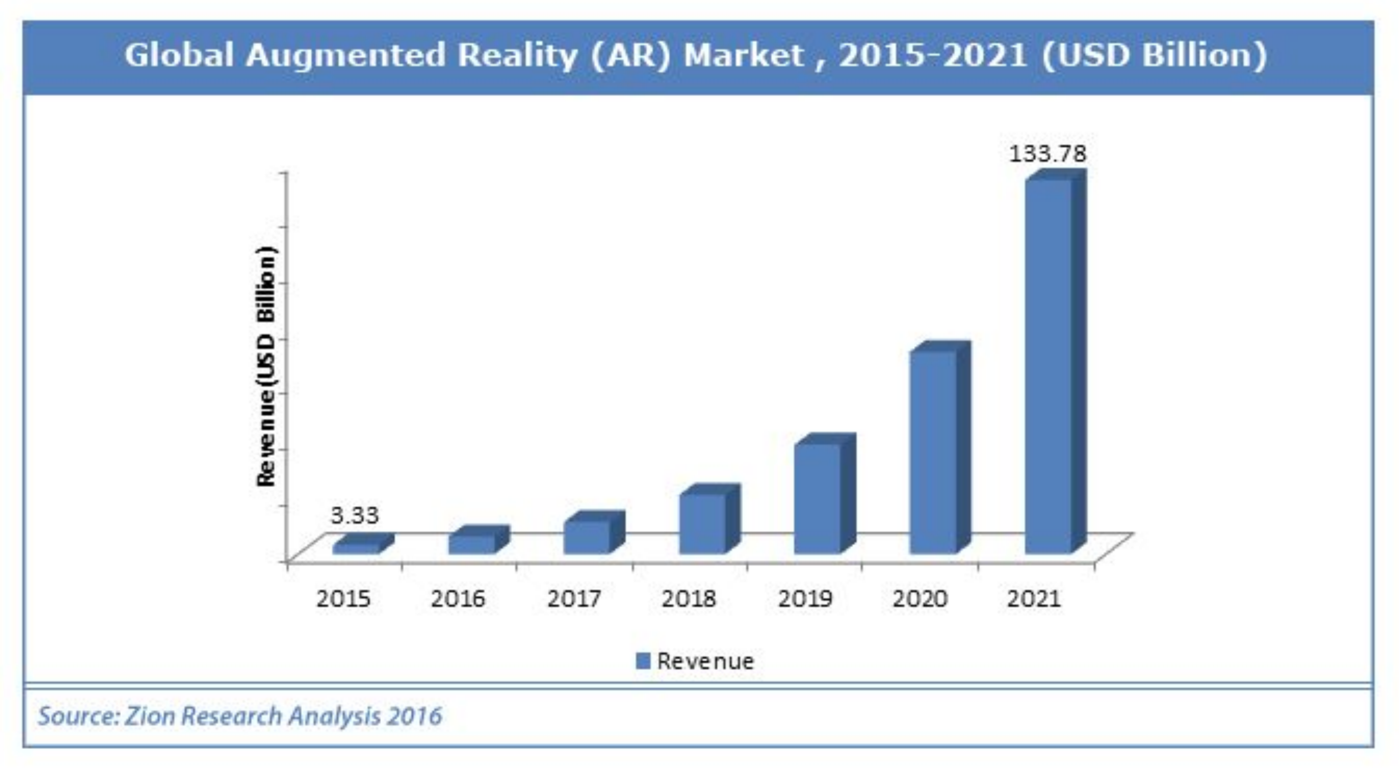
Is interactive in real time

Market Use



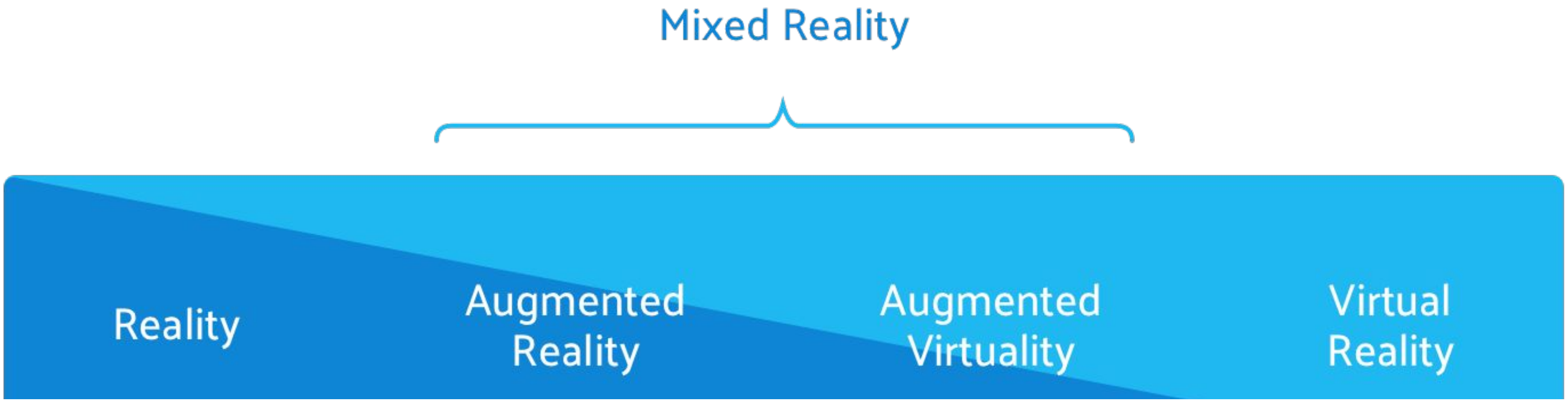
69
60.375
51.75
43.125
34.5
25.875
17.25
8.625
0
Y: Frequency
X: Number of products v...
6.25
12.5
18.75
25
31.25
37.5
43.75
Z: Time spent (seconds)
3700
3237.875
2775.75
2313.625
1851.5
1389.375
927.25
465
Leave
[ESC] to leave
Legend
Mapping
Legend Insights
Smart Mapping
Cluster
Outlier Detection
Datasets History

A Growing Market.



$100 bn

By 2021, AR market is expected to cross over $100 bn, What’s the difference between **Augmented Reality** and **Virtual Reality** ?


Mixed Reality
Reality
Augmented Reality
Augmented Virtuality
Virtual Reality

4. Four Types of AR

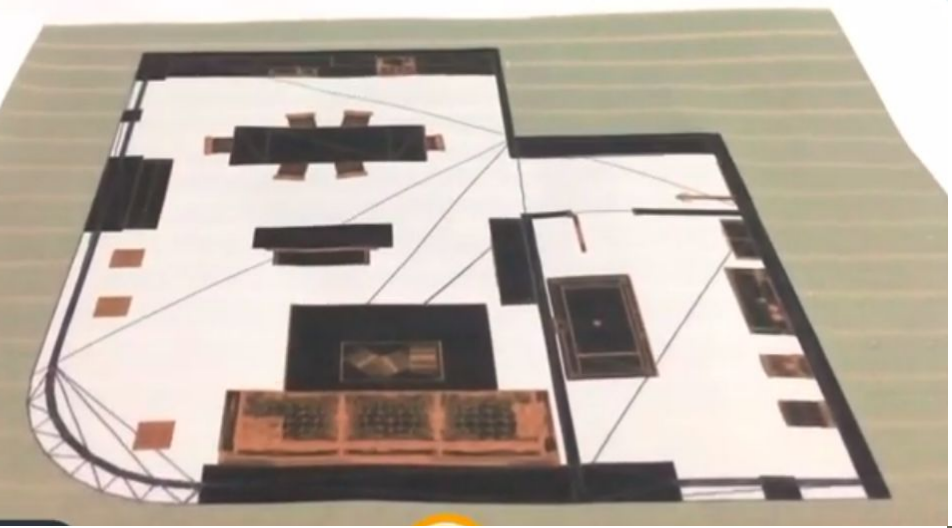
- Marker Based AR
- Marker-less AR
- Projection Based AR
- SuperImposed Based AR

Marker Based AR

- *Markers* are distinct patterns that cameras can easily recognize and process. Markers are visually unique from the environment around them.

- Software, usually in the form of an *app*, enables users to scan markers from their device using its camera feed.

- Scanning a marker triggers an augmented experience, whether it be an object, text, or animation, to appear on the device.




Stop

Marker-less AR

- Marker-less augmented reality is one of the most widely implemented applications in the industry. It is also known as Location-based AR.

- This type of app is mostly used to help travelers. Apart from that, it helps users to discover interesting places within their current location.

- This method works by reading data from the mobile's GPS, accelerometer and adds location information on screen about the objects that can be seen from the user's camera.

- Popular game released in 2016
- Most downloaded mobile game in its first month

Projection Based AR

- As is obvious by the name, projection based AR functions using projections onto objects.

- This type of app is mostly used to help travelers. Apart from that, it helps users to discover interesting places within their current location.

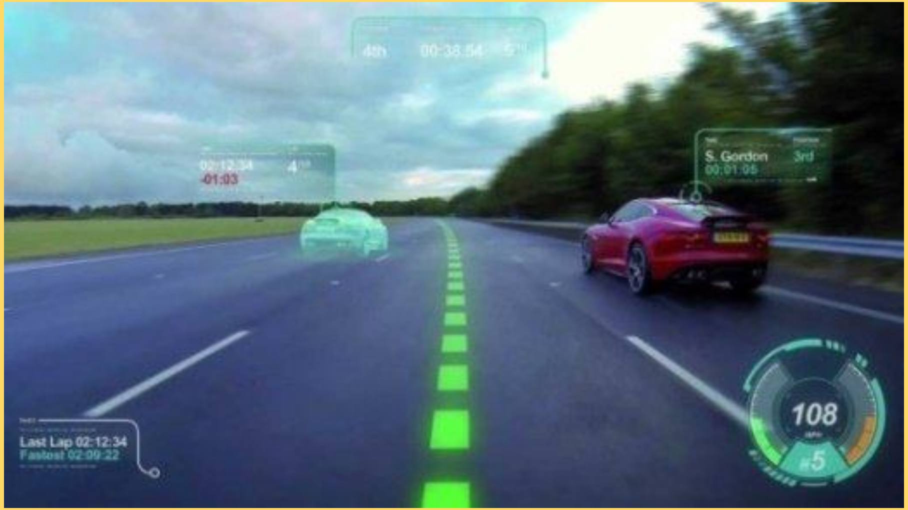
- This method works by reading data from the mobile's GPS, accelerometer and adds location information on screen about the objects that can be seen from the user's camera.


Search

Superimposition Based AR

- Superimposition based AR provides an ‘alternate’ view of the object in concern, either by replacing the entire view with an augmented view of the object or by replacing a portion of the object view with an augmented view.

- In this case, once again, object recognition plays a vital role - logically, if the application does not know what it is looking at, it most certainly cannot replace the original view with an augmented one.


4th
00:38:54
02:12:34
-01:03
S. Gordon
3rd
00:01:05
Last Lap 02:12:34
Fastest 02:09:22
108

The basics of AR functionality

1. Placing and Positioning Assets

- There are a few basic rules that augmented reality creators need to remember about the way objects behave in AR.
- These behaviors are the key to merging the real and digital worlds seamlessly. The first of these behaviors is place.
- Stationary AR objects need to stick to one point in a given environment. This can be something concrete such as a wall, floor, or ceiling, or it could be suspended somewhere in mid air.

The basics of AR functionality

2. Scale and Size of Assets
    - AR objects need to be able to scale.
    - When a car is coming toward you from a distance, it starts out small and gets bigger. A painting viewed from the side looks very different when you walk around and face it head on.
    - Our physical distance from a given object and our orientation around it changes how they appear to us.
    - A well-constructed AR experience will incorporate objects that are not only appropriately placed, but will look different if you stand right next to it, below it, above it, or view it from far. This is scaling.

The basics of AR functionality

3. Occlusion

- Occlusion means hiding virtual objects behind other virtual objects, and ones in the real world.

- AR hardware has to not only understand where the object is in the room but also its relative distance from the user compared with any other objects physical or digital.

The basics of AR functionality

4. Lighting for increased realism

- Just like a real world object, objects in AR need to respond to different patterns of lighting to make sense in our minds.

- The colors, shading, and shadows cast by these objects all need to behave properly both in the initial lighting of a scene and in the case of a lighting change.

The basics of AR functionality

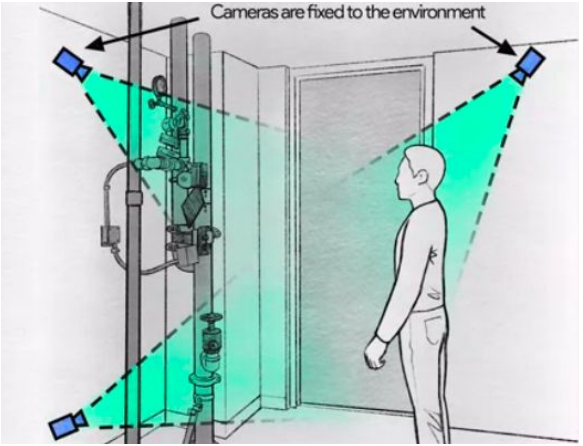
5. Tracking

    - Tracking is the process of tracing the scene coordinates of moving objects in real-time

    - For AR, there's two ways tracking happens, inside-out tracking and outside-in tracking

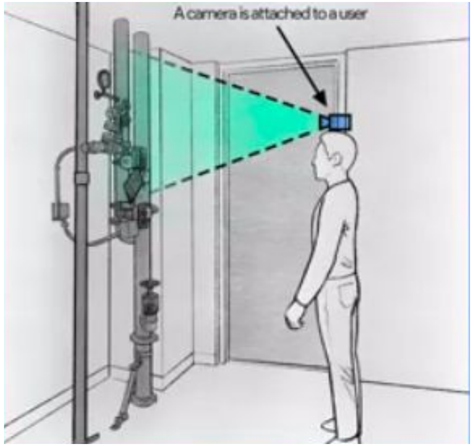
(a) Outside-In Tracking

With Outside-in Tracking, cameras or sensors aren't housed within the AR device itself. Instead, they're mounted elsewhere in the space.



(b) Inside-Out Tracking

With inside-out tracking, cameras and sensors are built right into the body of the device. Smartphones are the most obvious example of this type of tracking.



The basics of AR functionality

6. Motion Tracking

- One of the most important things that systems like AR do is motion tracking. AR platforms need to know when you move.

- This requires data collecting hardware like cameras, depth sensors, light sensors, gyroscopes, and accelerometers.

- ARCore uses all of these to create an understanding of your environment and uses that information to correctly render augmented experiences by detecting planes and feature points to set appropriate anchors.

The basics of AR functionality

6. Motion Tracking (contd.)

   - AR systems tell a smartphone where it's located in space in relationship to the world around it. It does this by capturing visually distinct features in your environment. These are called feature points.

   - These feature points can be the edge of a chair, a light switch on a wall, the corner of a rug, or anything else that is likely to stay visible and consistently placed in your environment

   - Many smartphones in existence today have
     Gyroscopes - for measuring the phones angle
     Accelerometers - for measuring the phones speed

Simultaneous Localization And Mapping

Given a input from series of controls u_t and sensor observations o_t over discrete time steps t, the Simultaneous Localization and Mapping problem is to compute an estimate of the agent's location x_t and a map of the environment m_t. All quantities are usually probabilistic, so the objective is to compute:

$$P(m_{t+1}, x_{t+1} | o_{1:t+1}, u_{1:t})$$

The following uses an complex expansion using Bayes' Rule and then two such beliefs are put in expectation-maximization algorithm(optimizing to a local optimum).

The basics of AR functionality

7. Feature Points and Plane-Finding

    - Environmental understanding, is process for seeing, processing and using information about the physical world around an AR device.

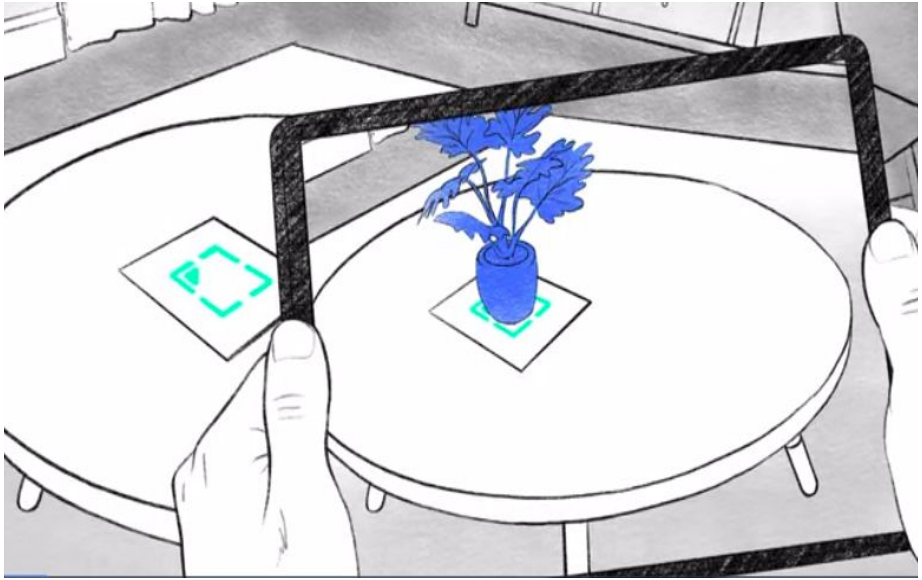
    - The process begins with feature points. The same feature points used for motion tracking.

    - Phone's camera is used to capture clusters of feature points along a surface. To create what's known as a plane. Plane finding is the term for ability to detect and generate flat surfaces.

The basics of AR functionality

8. Anchors
    - Once you have analyzed your surrounding and placed planes and reference points where they belong, you'll should set anchors for your AR objects.

    - Anchors, also referred to as anchor points, are the points in your environment that should always hold the respective digital object.



Some Well Known Feature Points Detection Algorithms -

- SIFT - Scale-invariant feature transform
- SURF - SpeedUp Robust Features
- FAST - Features from Accelerated Segment Test
- BRIEF - Binary Robust Independent Elementary Features
- ORB - Oriented FAST and Rotated BRIEF
- BRISK - Binary Robust Invariant Scalable Keypoints

Introduction to FAST (Features from Accelerated Segment Test).

- ***Features from accelerated segment test (FAST)*** is a corner detection method, which could be used to extract feature points and later used to track and map objects.

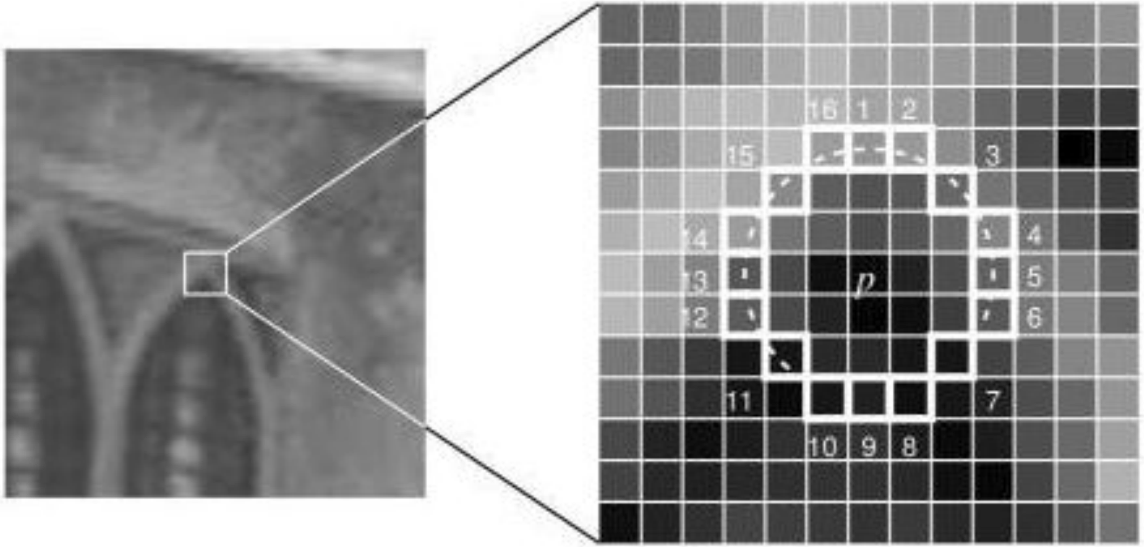
- The FAST corner detector is very suitable for real-time video processing application because of this high-speed performance.

Story for illustration purposes only

Feature detection using FAST

Steps:

1. Select a pixel ***p*** in the image which is to be identified as an interest point or not. Let its intensity be ***Ip***.
2. Select appropriate threshold value ***t***.
3. Consider a circle of 16 pixels around the pixel under test. (This is a Bresenham circle of radius 3.)
4. Now the pixel ***p*** is a corner if there exists a set of ***n*** contiguous pixels in the circle (of 16 pixels) which are all brighter than ***Ip + t***, or all darker than ***Ip - t***. (The authors have used ***n***= 12 in the first version of the algorithm).


16 1 2
15
3
14
4
13
p
5
12
6
11
7
10 9 8

Feature detection using FAST

Steps:

5. If at least three of the four-pixel values— ***I1, I5, I9, I13*** are not above or below ***Ip+t***, then ***p*** is not an interest point (corner). In this case reject the pixel ***p*** as a possible interest point. Else if at least three of the pixels are above or below ***Ip+t***, then check for all 16 pixels and check if 12 contiguous pixels fall in the criterion.

6. Repeat the procedure for all the pixels in the image.

Smartphone app using Google's ARCore to find planes