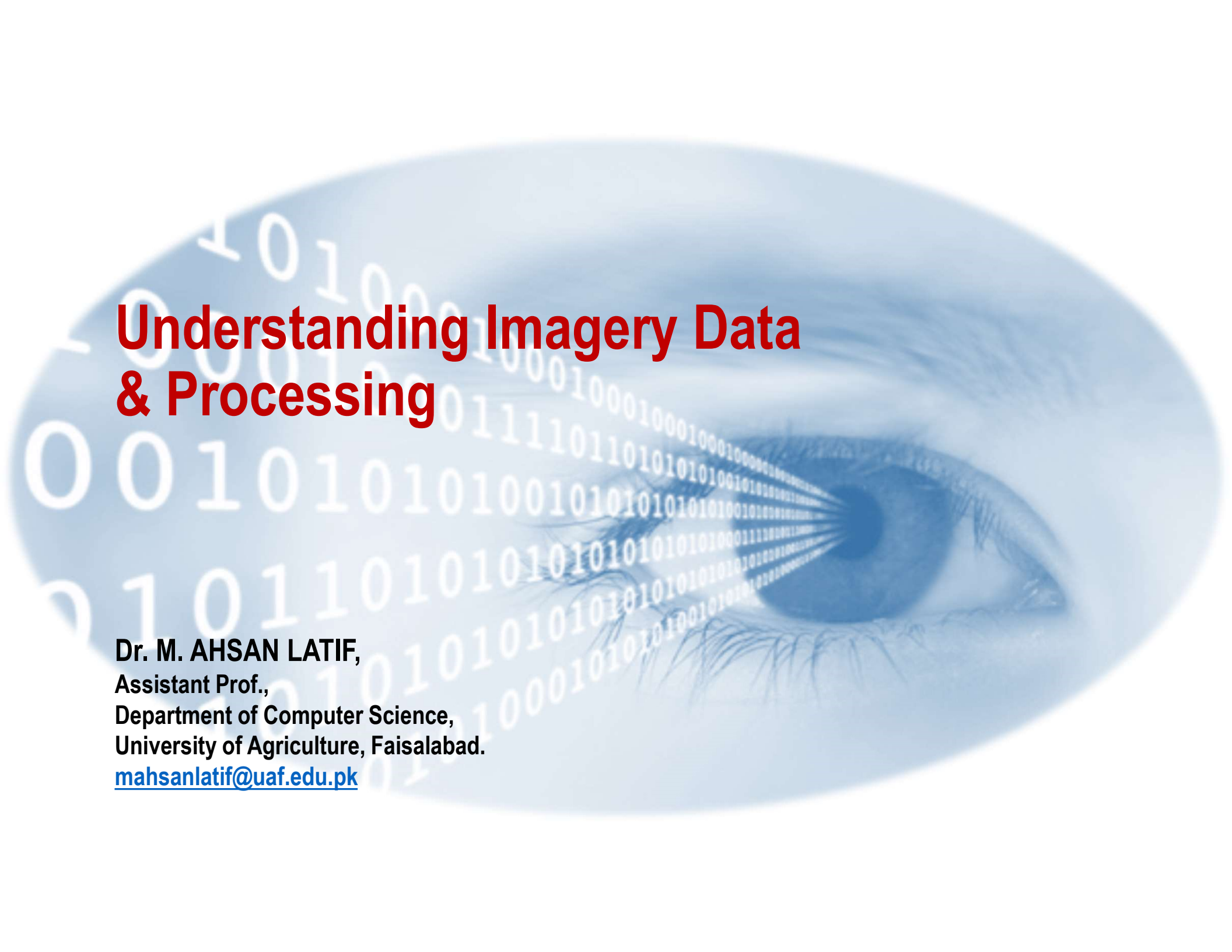


Understanding Imagery Data & Processing

Dr. M. AHSAN LATIF,
Assistant Prof.,
Department of Computer Science,
University of Agriculture, Faisalabad.
mahsanlatif@uaf.edu.pk

Contents

Image Basics

- What is an Image?
- Image Formation
- Pixel
- Resolution & its Types
- Image Types
- Color Models
- **Image as Matrix**

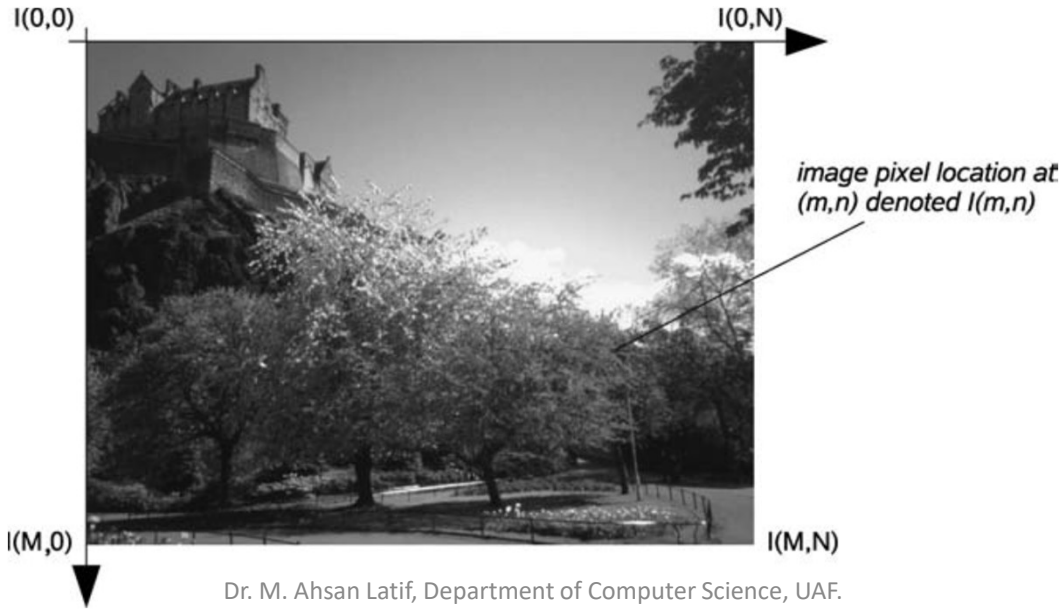
Image Processing

- Spatial Domain
- Frequency Domain
- Filtering
- Geometric Transformations
- Computer Vision / Machine Vision
- Applications

What is a Digital Image?

A digital image is a discrete representation of data **possessing both spatial (layout) and intensity (colour) information.**

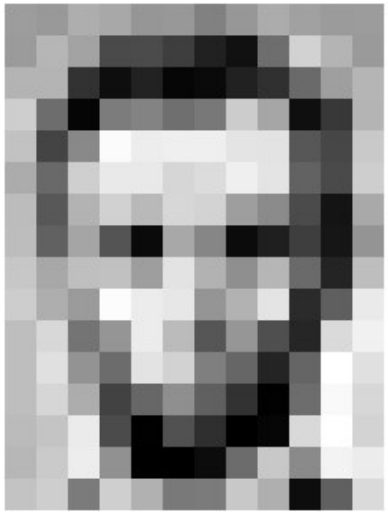
The two-dimensional (2-D) discrete, digital image I(m, n) represents the response of some sensor at a series of fixed positions (m = 1, 2, ……, M; n = 1, 2, ……, N) in 2-D Cartesian coordinates and is derived from the 2-D continuous spatial signal I(x,y) through a sampling process frequently referred to as discretization.

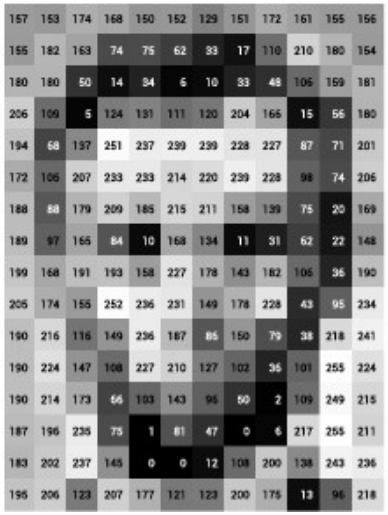


Pixel

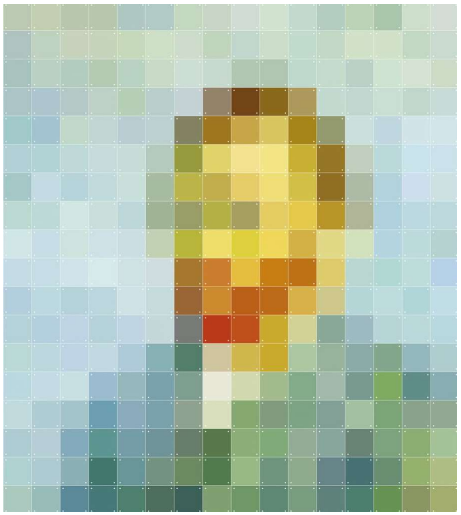
- The word pixel is an abbreviation of ‘picture element’.
- Indexed as an (x, y) location from the origin of the image.
- It represents the smallest, constituent element in a digital image
- Contains a numerical value which is the basic unit of information.
- Each pixel is a sample of an original image for a particular point.

- 1 bpp, 2^1 = 2 colors (monochrome)
- 2 bpp, 2^2 = 4 colors
- 3 bpp, 2^3 = 8 colors
- …
- 8 bpp, 2^8 = 256 colors
- 16 bpp, 2^{16} = 65,536 colors ("Highcolor")
- 24 bpp, 2^{24} = 16,777,216 colors ("Truecolor")





157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

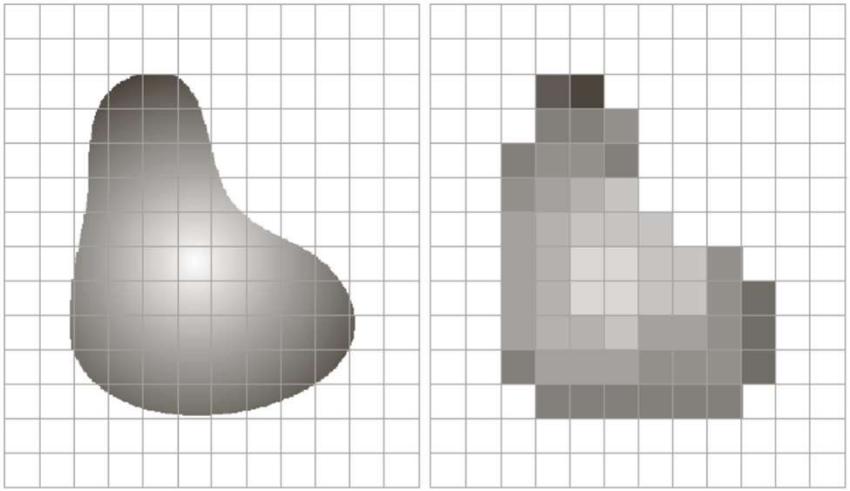


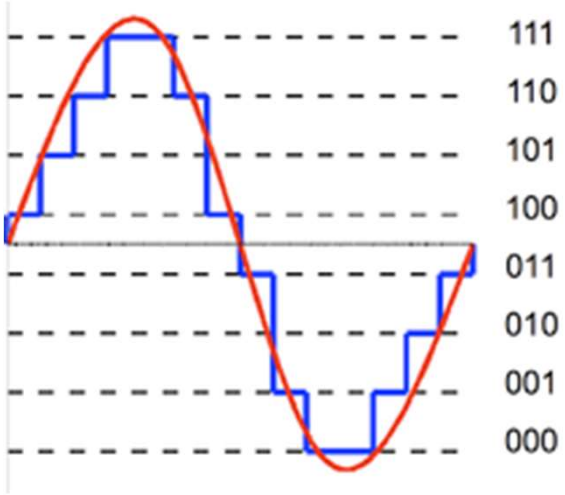
Mathematically Speaking an Image is a Matrix

$$
\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ \vdots \\ m \end{array}
\begin{array}{c}
\begin{array}{cccc} 1 & 2 & \dots & n \end{array} \\
\left[\begin{array}{cccc}
a_{11} & a_{12} & \dots & a_{1n} \\
a_{21} & a_{22} & \dots & a_{2n} \\
a_{31} & a_{32} & \dots & a_{3n} \\
\vdots & \vdots & \vdots & \vdots \\
a_{m1} & a_{m2} & \dots & a_{mn}
\end{array}\right]
\end{array}
$$

Sampling & Quantization

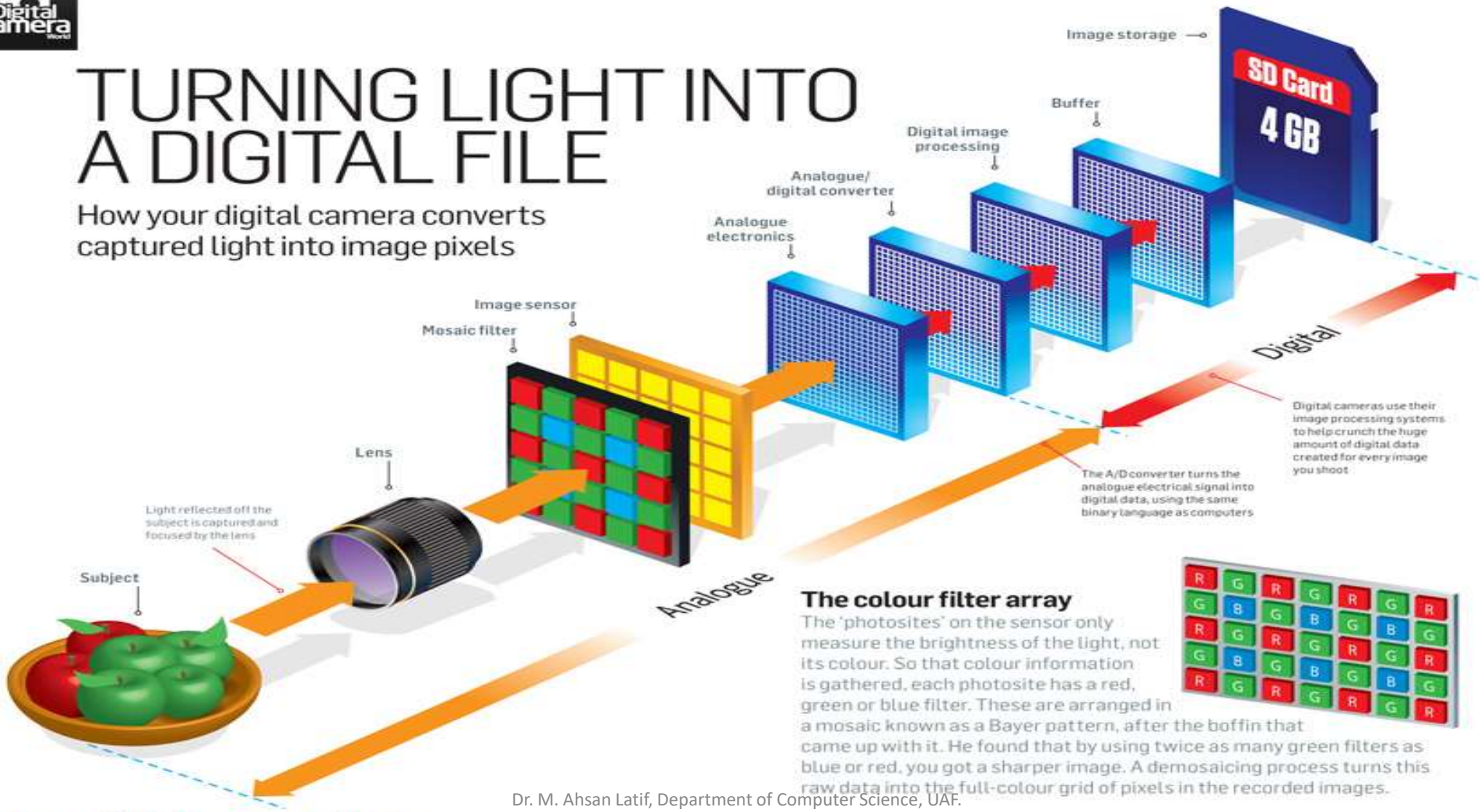
- Sampling corresponds to a discretization of the space.
- Quantization corresponds to a discretization of the intensity values.





TURNING LIGHT INTO A DIGITAL FILE

How your digital camera converts captured light into image pixels



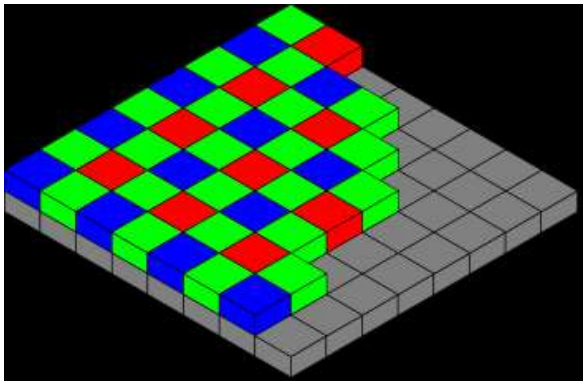
The colour filter array

The 'photosites' on the sensor only measure the brightness of the light, not its colour. So that colour information is gathered, each photosite has a red, green or blue filter. These are arranged in a mosaic known as a Bayer pattern, after the boffin that came up with it. He found that by using twice as many green filters as blue or red, you got a sharper image. A demosaicing process turns this raw data into the full-colour grid of pixels in the recorded images.

www.digitalcameraworld.com

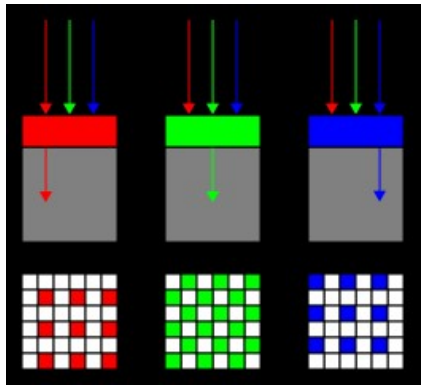
Image Sensor

- A sensor that detects information to constitute an image
- It converts the light-waves into signals



Color Filter Array

- CFA is a mosaic of tiny color filters placed over an image sensor to capture color information.
- Bayer Filter Sensor, Foven X3 Sensor, 3CCD, etc.

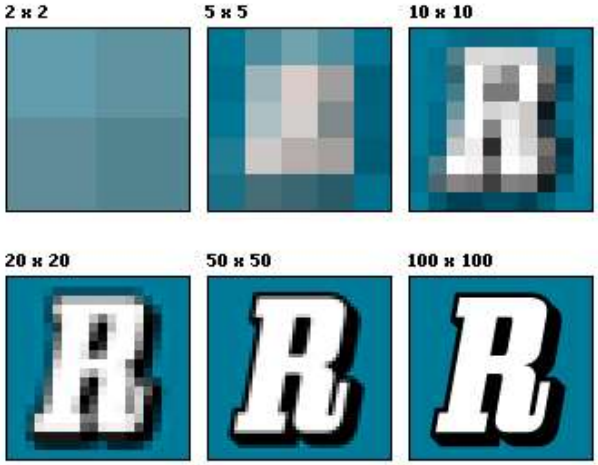


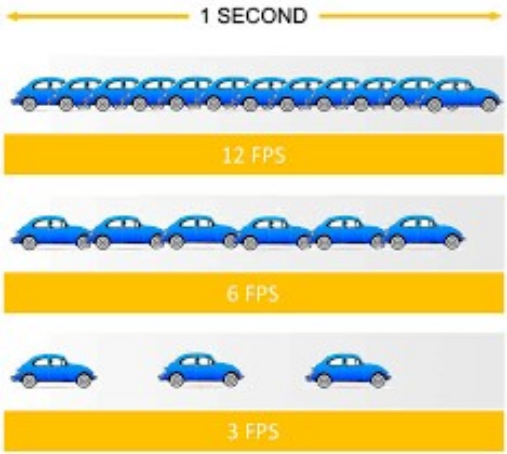
Width	Height	Aspect Ratio	Total Pixels	Mega Pixels
100	100	1:1	10,000	0.01
640	480	4:3	307,200	0.3
4900	2580	16:9	12,642,000	12.6

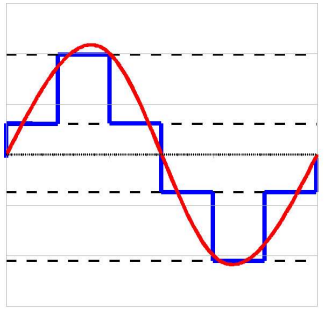
Image Resolution

The representational power of an image is defined by its resolution.

- Spatial Resolution
- Temporal Resolution
- Bit Resolution







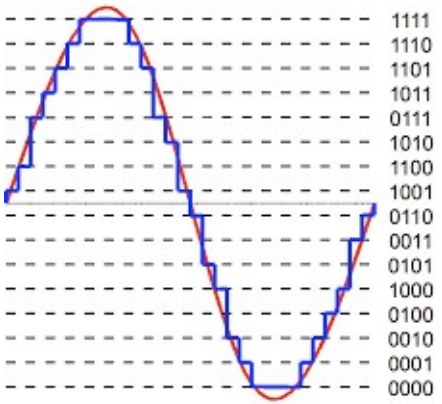
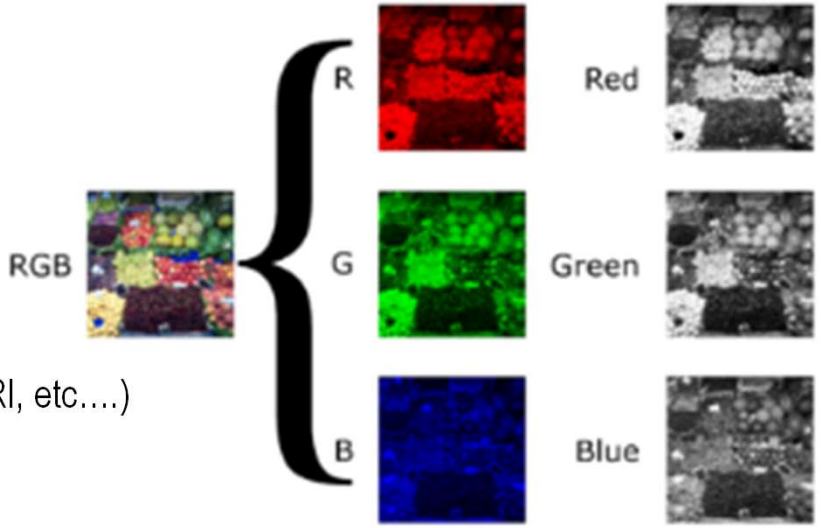
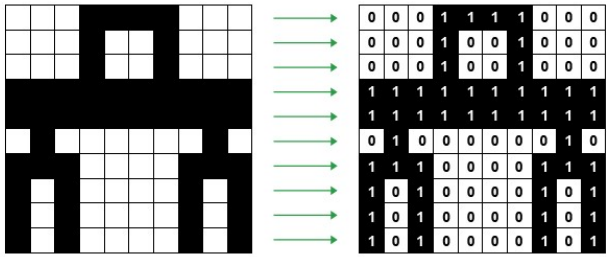
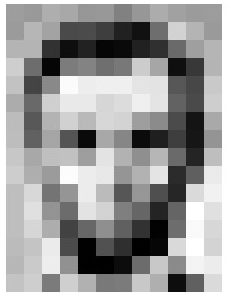


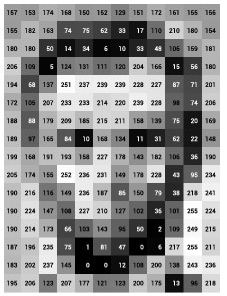
Image Types

- Binary
- Grayscale
- True Color
- Indexed
- Multispectral
- Hyperspectral
- Medical (X-ray, MRI, etc….)
- Etc…..





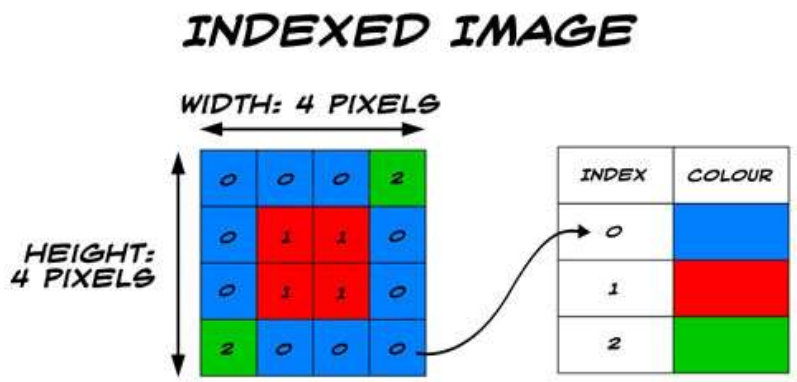




Binary

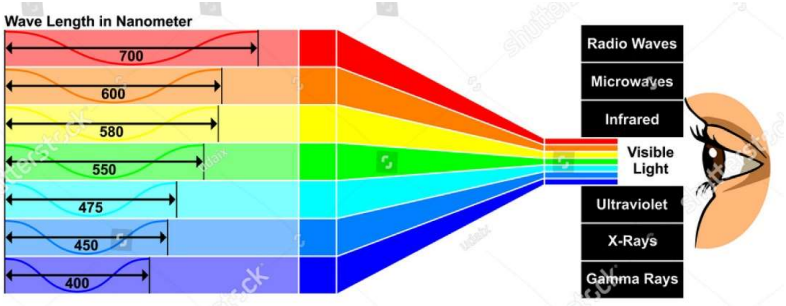
Grayscale

Color



Multispectral Image

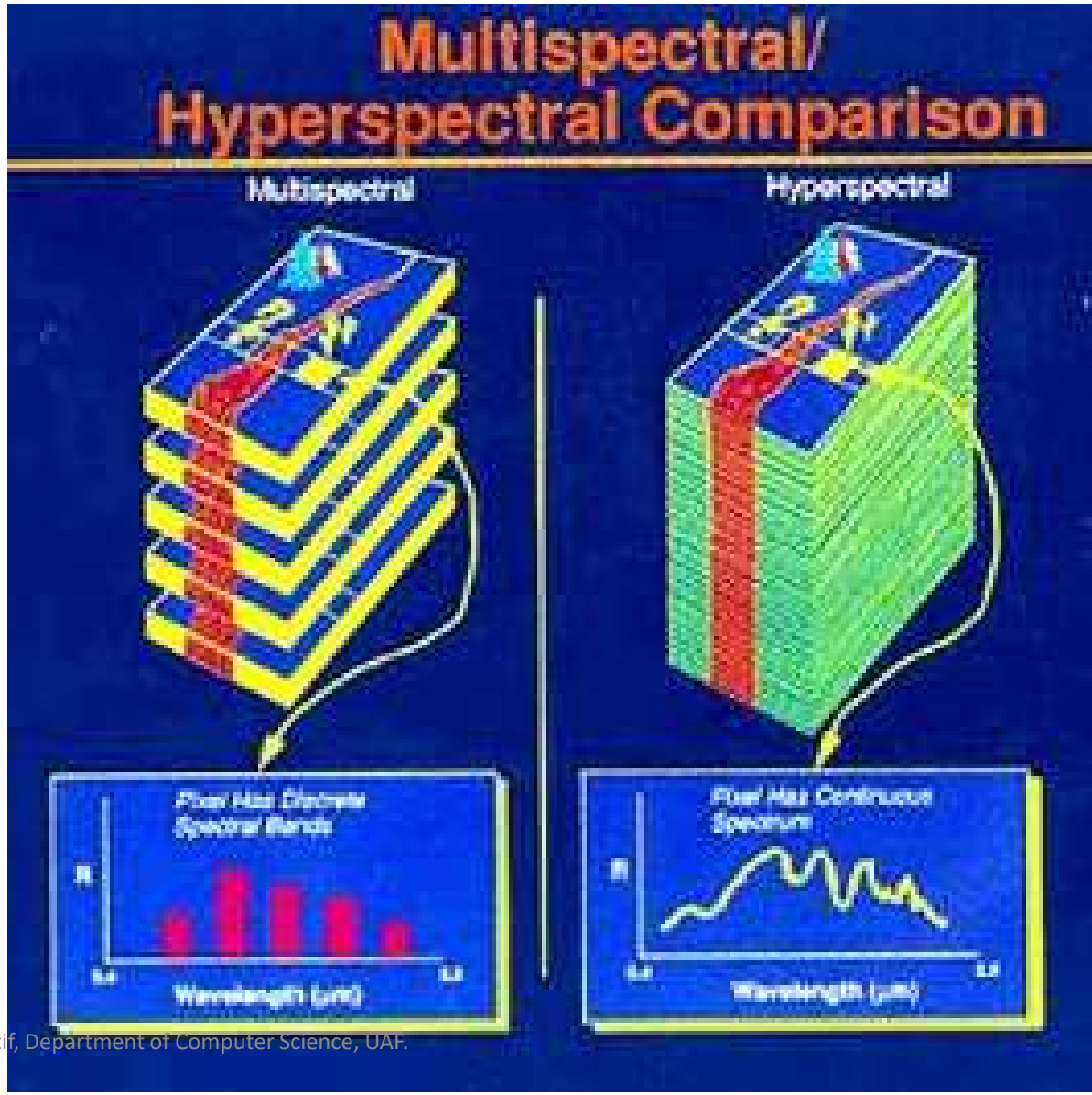
A multispectral image is one that captures image data within specific wavelength ranges across the electromagnetic spectrum.



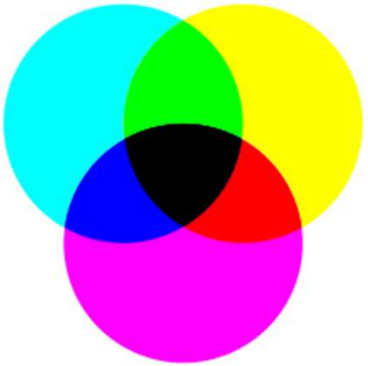
Coastal	coastal applications, water penetration, deep water masks materials differentiation, shadow-tree-water differentiation
Blue	coastal applications, water body penetration, discrimination of soil/vegetation, forest types, reef cover features
Green	crop types, sea grass and reefs, bathymetry
Yellow	leaf coloration, plant stress, CO_2 concentration, algal blooms, sea grass and reefs, separability of iron formations, "true color"
Red	chlorophyll absorption, vegetation analysis, plant species and stress
Red Edge	vegetation health, stress, type and age, sea grass and reefs land/no land, impervious from vegetated, turbidity, camouflage
NIR1	biomass surveys, plant stress delineation of water bodies, soil moisture discrimination
NIR2	biomass surveys, plant stress materials differentiation

Hyperspectral vs Multispectral Imaging

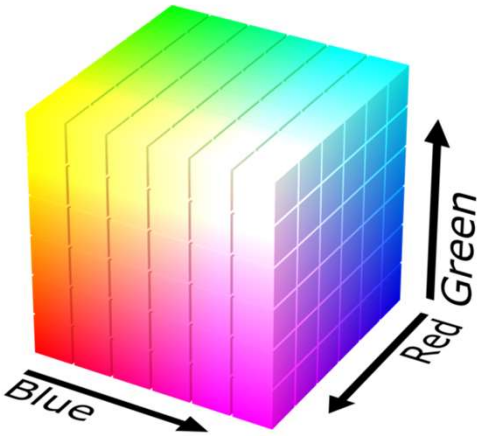
Hyperspectral imaging (HSI) uses continuous and contiguous ranges of wavelengths (e.g. 400 - 1100 nm in steps of 1 nm) whilst multispectral imaging (MSI) uses a subset of targeted wavelengths at chosen locations (e.g. 400 - 1100 nm in steps of 20 nm).

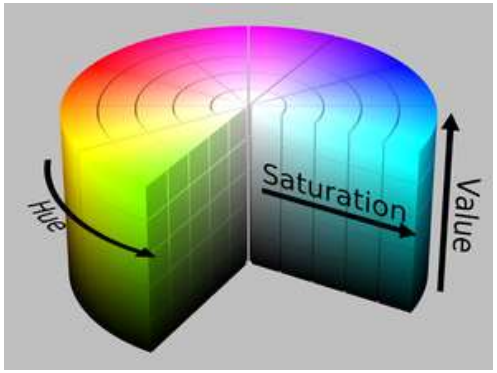


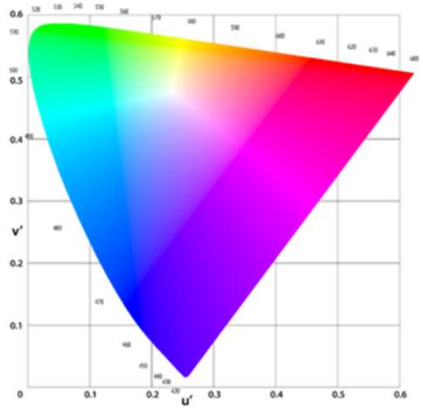
Color Models



CMY







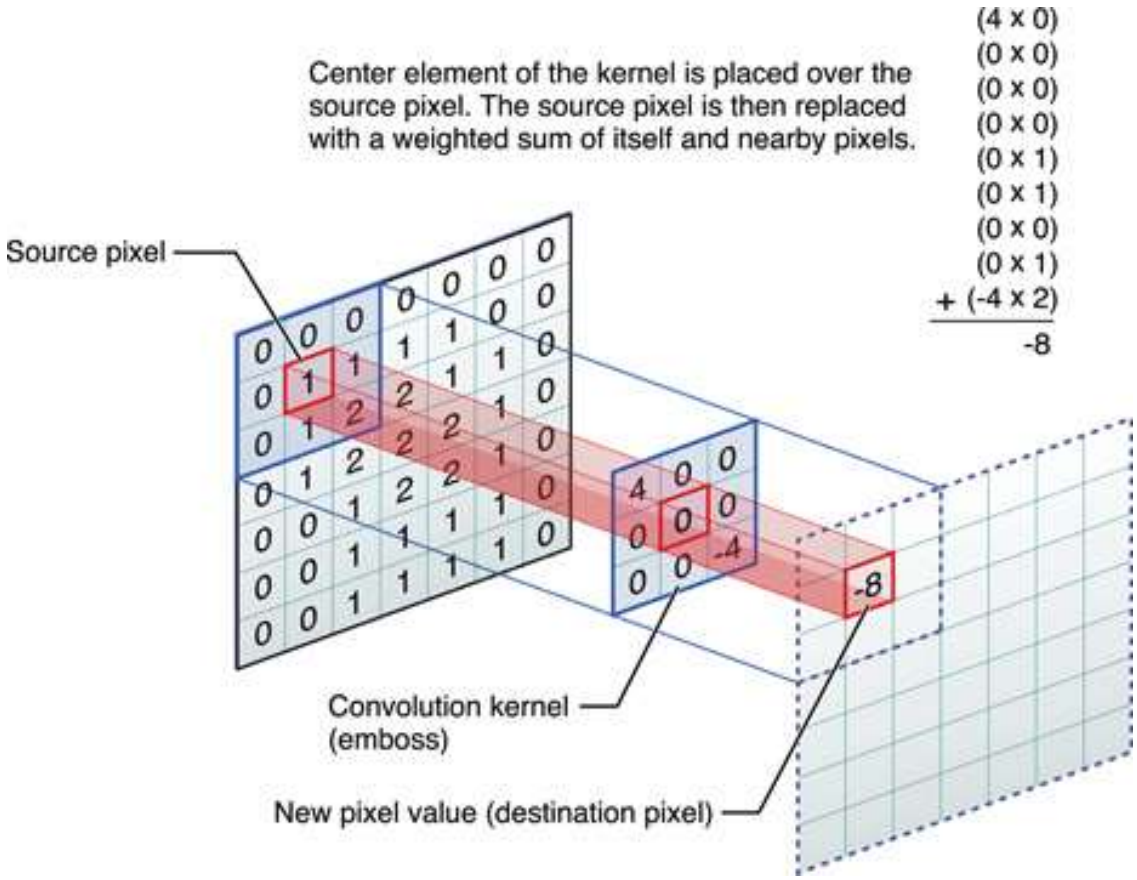
CIELUV

Digital Image Processing

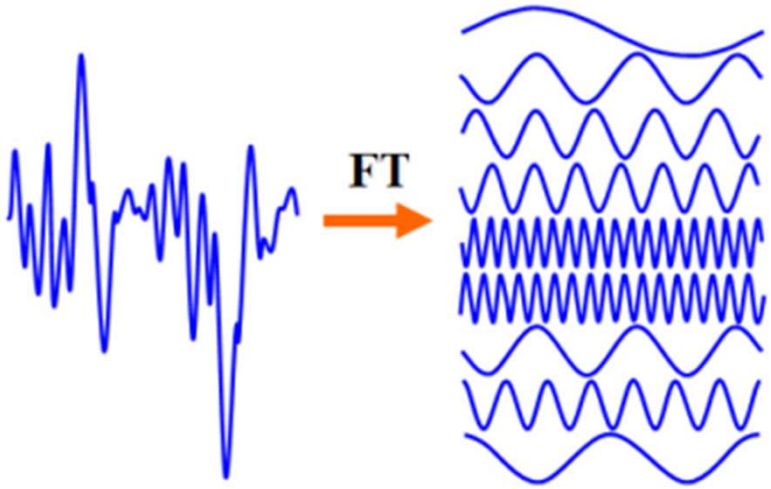
Processing of Digital Images through an Algorithm

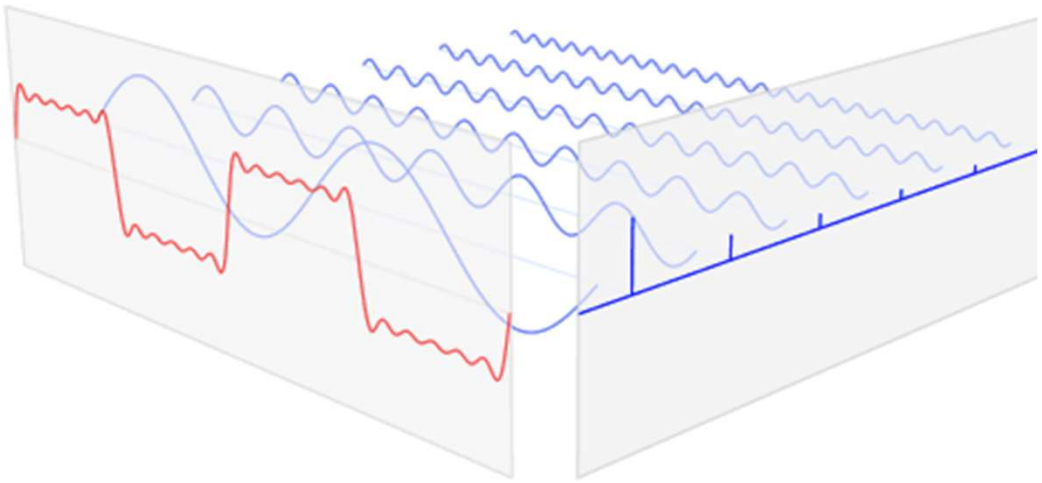
- Image quality enhancement
- Image segmentation
- Object detection
- Tracking
- Automatic inspection
- Assisting humans in identification tasks.
- Controlling processes, *e.g.*, an industrial robot
- Detecting events, *e.g.*, for visual surveillance
- Human computer Interactions
- Modeling objects or environments
- Navigation, *e.g.*, by an autonomous vehicle or mobile robot
- ----
- ----

Spatial Domain Processing

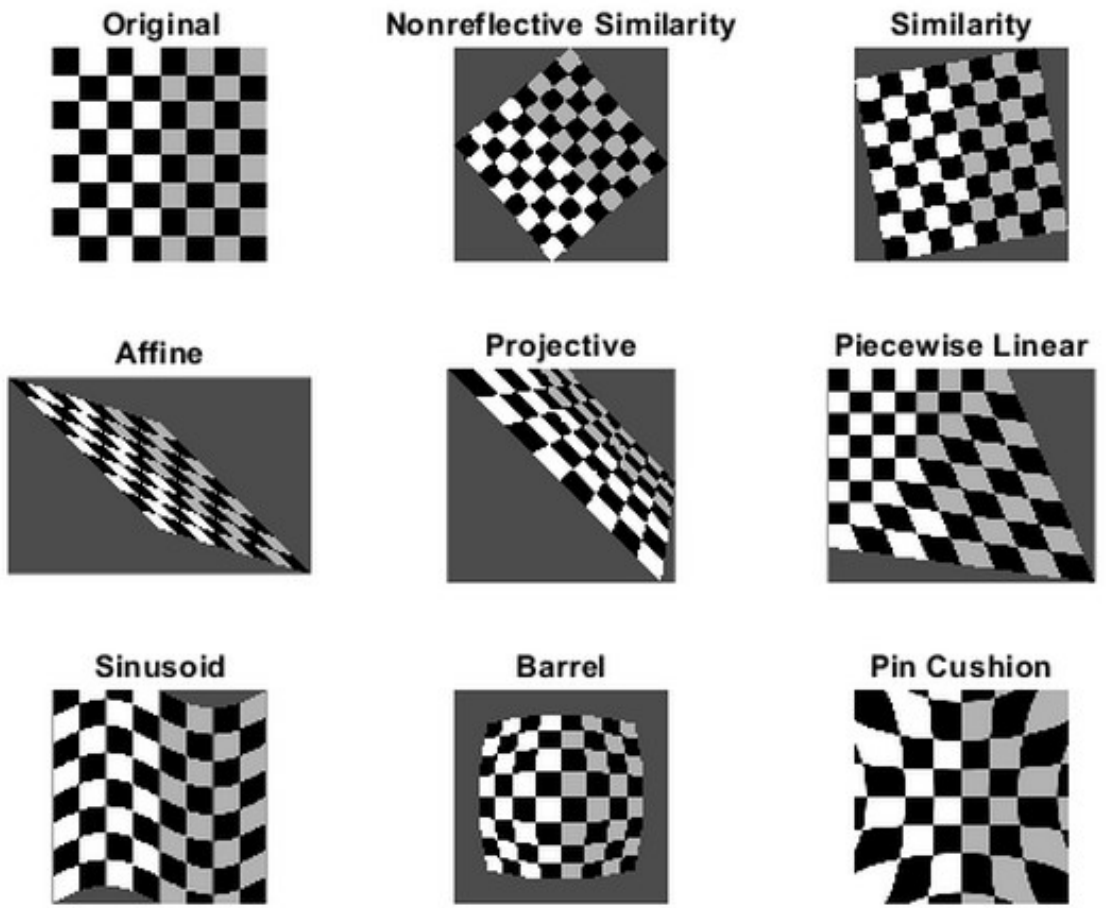


Frequency Domain Processing





Geometric Transformations



Camera Calibration

Camera calibration **estimates the parameters of a lens and image sensor of an image or video camera.**

- Correct lens distortion
- Measure the size of an object in world units
- Determine the location of the camera in the scene.

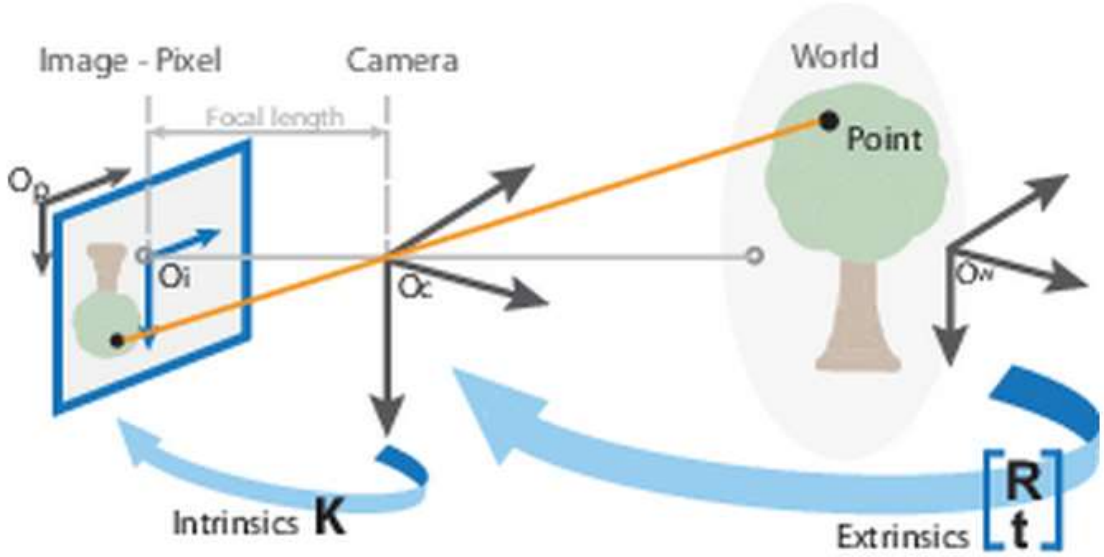
$$w\,[x\ y\ 1] = [X\ Y\ Z\ 1]\,P$$

Scale factor *Image points* *World points*

$$P = \begin{bmatrix} R \\ t \end{bmatrix} K$$

Camera matrix *Extrinsics* *Intrinsic matrix*

Rotation and translation



Output of Image Processing

- Image to Image
- Image to Derived Info
- Image to Decision Making

Image Features

- Features refer to a distinct structure found in an image, such as a point, edge, or small image patch.
- Usually differs from its surroundings by texture, color, or intensity.
- What the feature represents does not matter, just that it is distinct from its surroundings is important

Detectors	Descriptors
FAST	SURF
Harris	KAZE
ORB	FREAK
Shi & Tomasi	BRISK
SURF	ORB
KAZE	HOG
MSER	

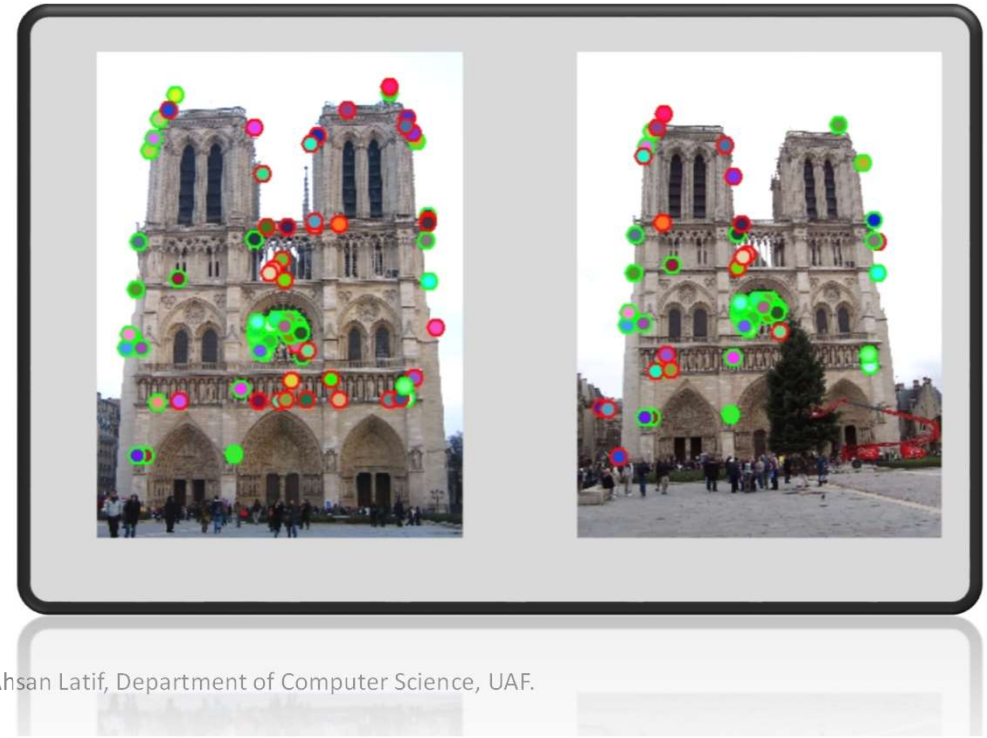
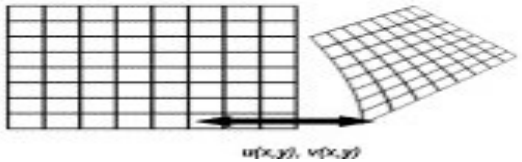
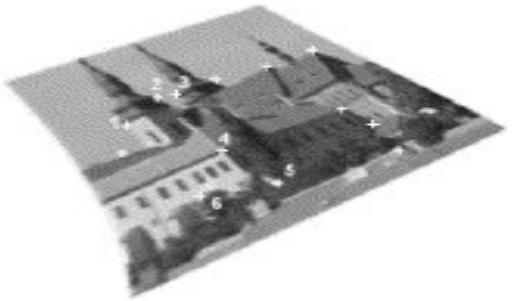
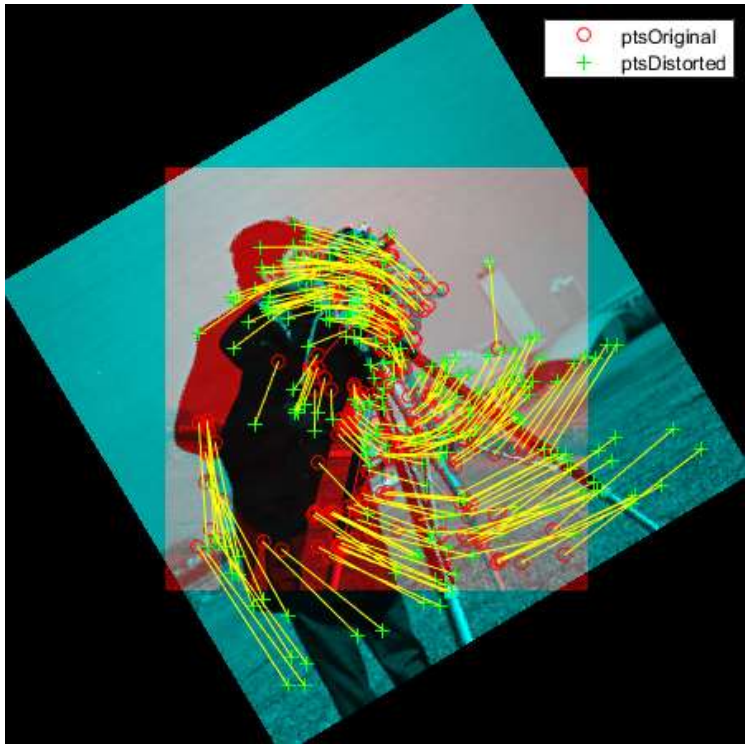


Image Registration

Align two images using intensity correlation, feature matching, or control point mapping





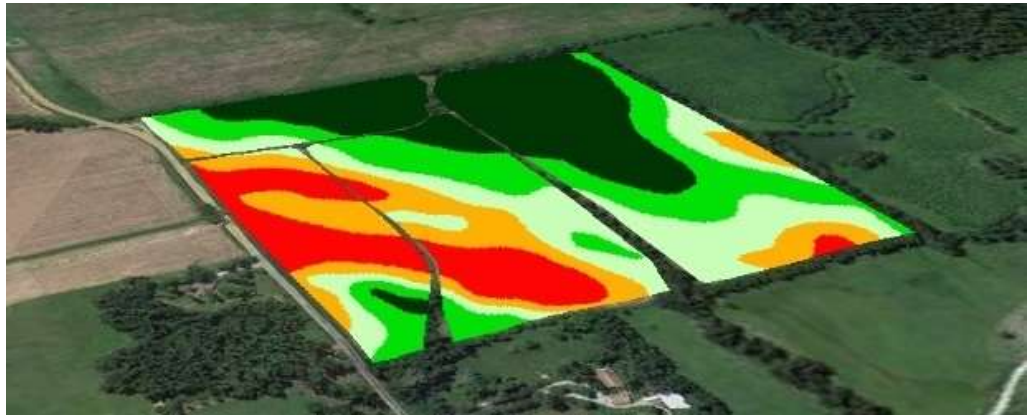

ptsOriginal
ptsDistorted

Satellites vs UAVs

Global but Low Resolution	**Spatial Resolution**	Local but High Resolution
Daily---Weeks	**Temporal Resolution**	User Dependent (No Time Constraint)
Mixed Signals, Noise, Needs Cloud-Free	**Data Quality**	High Precision, No-cloud interference

UAV – An Ideal Platform For Site-Specific Farming

Produce high yield by employing limited resources adaptively



Observation / Measurement / Response

- Spatial variations
- Temporal variations
- Inter-field / Intra-field

Better Yield @ Optimal resources

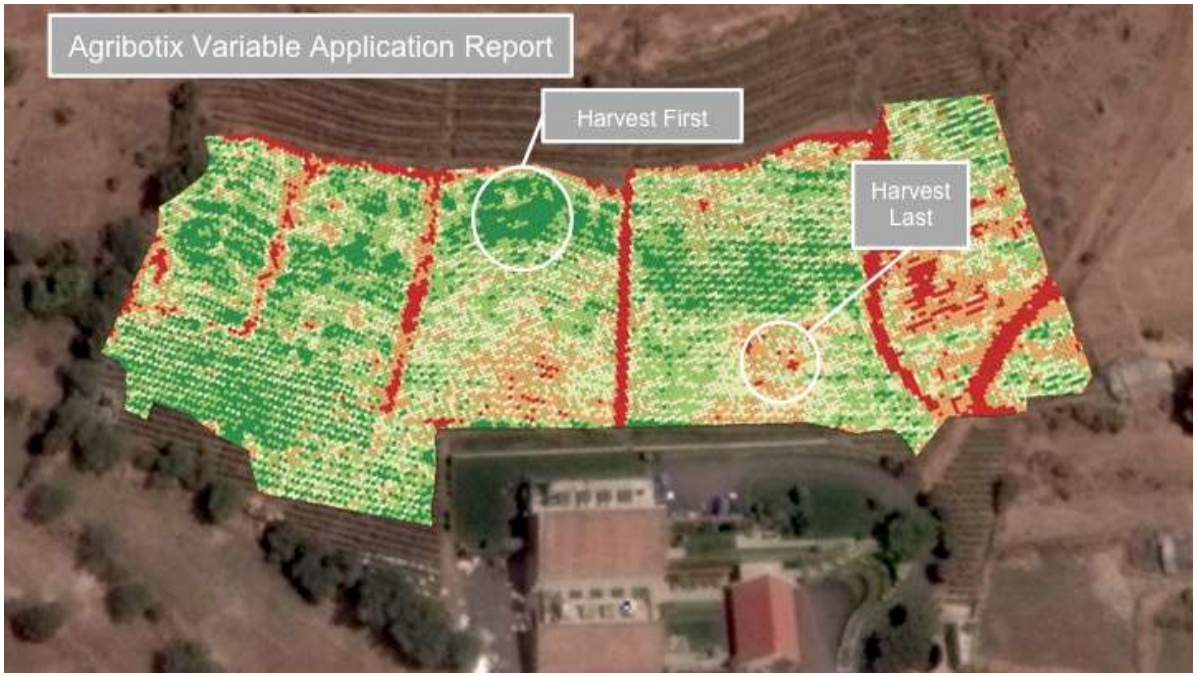
- Water
- Fertilizers
- Pesticides

Sr. No.	Major Project Goals	Quantifiable Indicators	Year-Wise Target			Total
			Year 1	Year 2	Year 3	
1	Establishment of Lab for High-Throughput Crop Phenotyping based on Aerial Intelligence	Procurement of Equipment Calibration of Sensors Selection of Experimental Sites	3			3
2	Crop Phenotyping by Estimating Geometric Traits	Development of Digital Maps to estimate Crop Height, Vegetation Cover Fraction, Fraction of Intercepted Radiation, Leaf Area Index, 3D Structure, Leaf Angle Distribution, Tiller Densities, Emergence.		10		10
3	Crop Phenotyping by Estimating Crop Physiological Traits	Development of Digital Maps based on Vegetation Indices to estimate Chlorophyll Content, Nitrogen Content, Protein Content, LAI, Water Content, Yield, Biomass			7	7
4	Early Season Weed Detection	Digital Maps to Detect Weeds in Wheat, Maize, Rice & Cotton.		4		4
5	Digital Aerial Counting of Crop Features	Cotton, Sunflower, Mustard		1	2	3
6	Crop Biotic / Abiotic Stress	Monitoring of Wheat / Cotton Growth under Biotic & Abiotic Stress		2	2	4
7	Technology Dissemination	Seminar(s), Business Plan, Publications			3	3

Agribotix™
Agricultural Intelligence. Drone-enabled.

Wine Grapes - India

The quality of grapes is mapped to determine when to harvest.



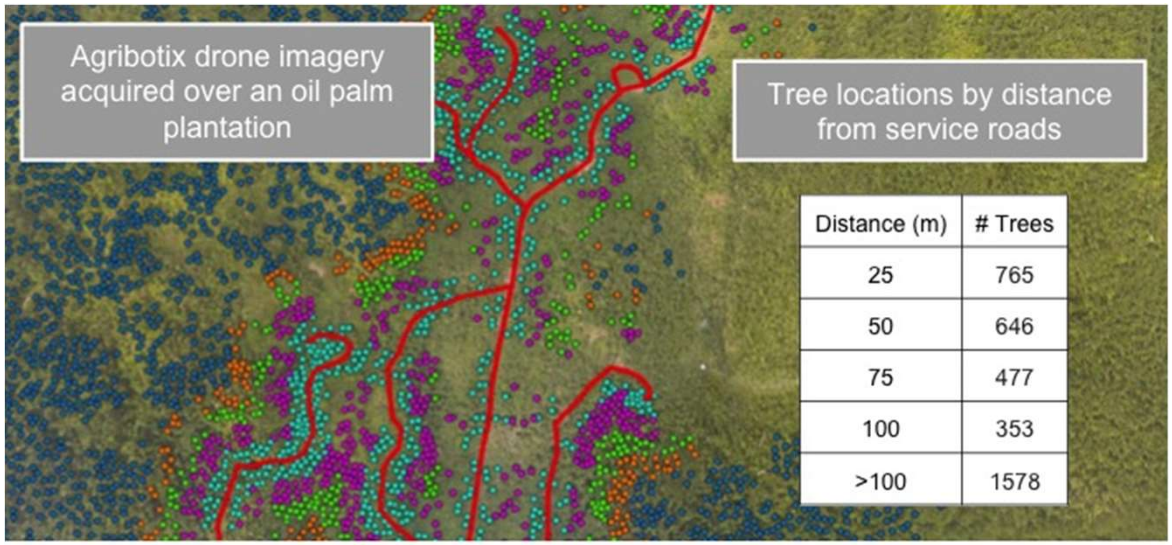
Agribotix
Agricultural Intelligence. Drone-enabled.

Cotton - Australia

Measured vegetation health in ***Wimmera Mallee***

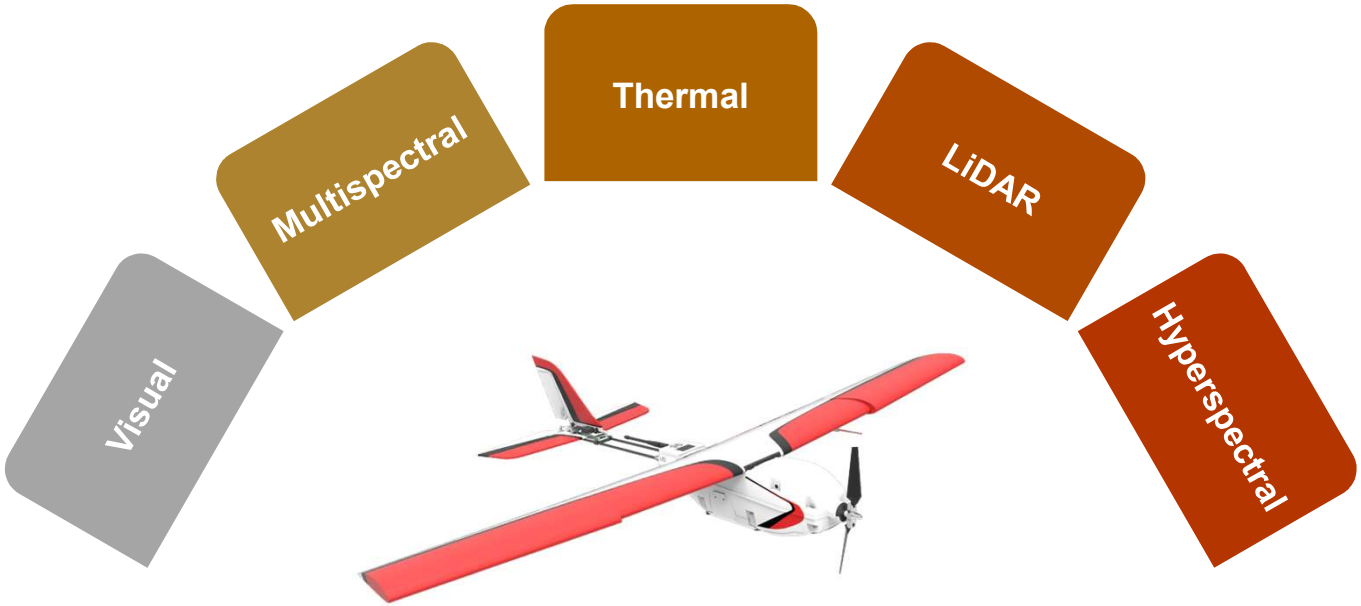
Agribotix™
Agricultural Intelligence. Drone-enabled.

Oil Palm Mapping & Infrastructure Analysis, Malaysia



Distance (m)	# Trees
25	765
50	646
75	477
100	353
>100	1578

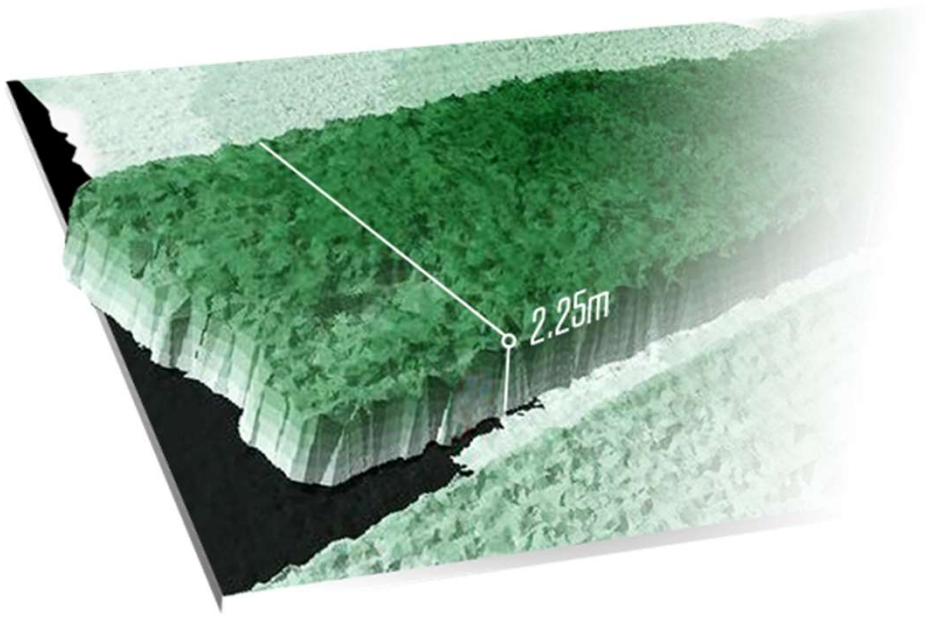
Available Sensors



Applications in Agriculture

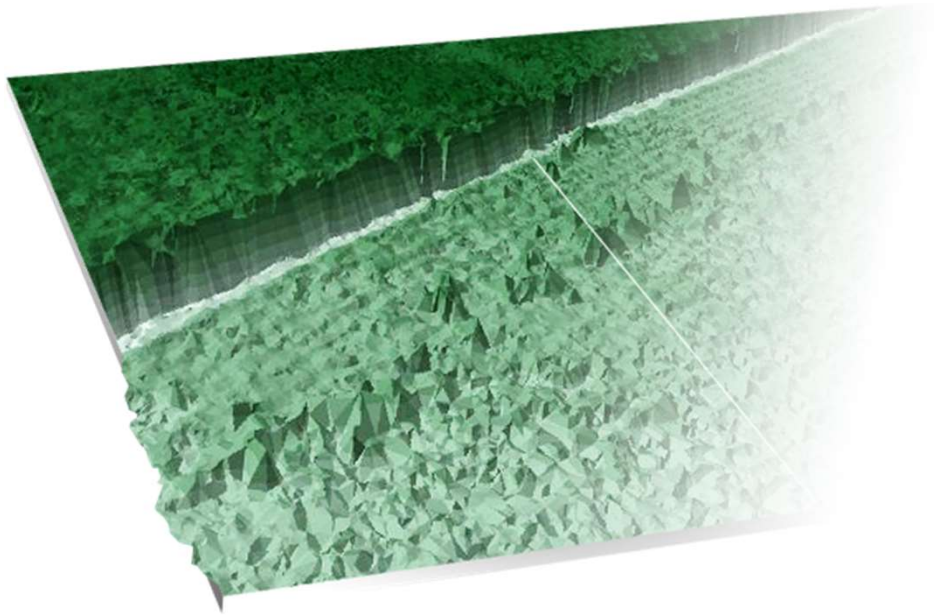
Plant Height

Provides 3D data to quickly assess **crop height and density** from any angle. Evaluate your crops for uniformity and yield potential.



Weed Detection

Another benefit of 3D data is the ability to see anomalies in the field commonly associated with weeds.

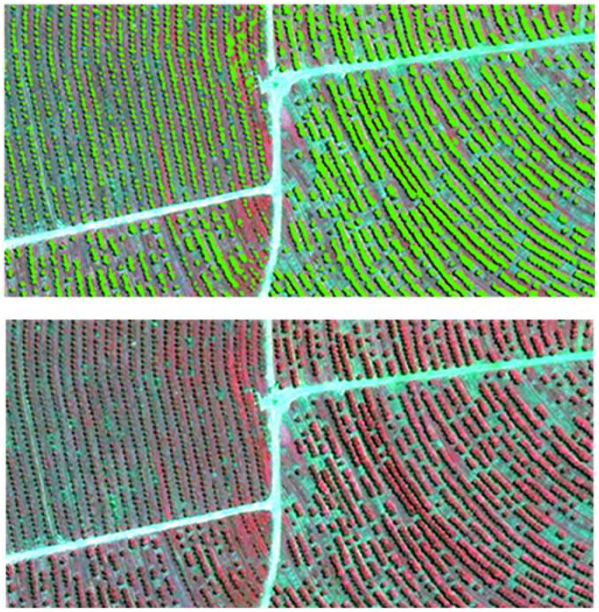


Plant Counting

High-resolution plant count maps are developed using a machine learning technology that gives users early information on plant size by individual plant, row, plot or field. Identify planter skips and assess yield potential in early growth stages.

Crop Cover

Quickly assess crop coverage reported as a coverage percentage.



Field statistics

- 9.6 ha Field Area
- 2.658 ha Crop Area
- 27.7% Crop Coverage

Thanks