Computer Vision

18AI742

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Computer Vision

Dr. D. Antony Louis Piriyakumar,
Dean (Research & Development)
Registered Indian patent agent (IN/PA 3041)

Computer vision

Contents

1) Course info
2) Assessment pattern
3) Definition of computer vision
4) Major subdomains
5) Current trends
6) Conclusion
7) Q&A

$$\nabla \cdot \mathbf{E} = \rho / \varepsilon_0$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \boldsymbol{j}_c$$

where

$$\nabla = \hat{\mathbf{i}} \frac{\partial}{\partial x} + \hat{\mathbf{j}} \frac{\partial}{\partial y} + \hat{\mathbf{k}} \frac{\partial}{\partial z}$$

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Course information

- Course code – 18 AI 742
- Instructor – Dr. D. Antony Louis Piriyakumar
- Level – B.Tech (7th semester)

Course contact hours

- Monday 08:55 am to 09:45 am (Theory)
- Monday 11:05 am to 12:00 pm (Tutorial)
- Tuesday 09:50 am to 10:45 am (Theory)
- Tuesday 02:30 pm to 03:25 pm (Tutorial)
- Thursday 11:05 am to 12:00 pm – (Theory)

Instructor -Contact detail

- Room 118 Dean's (R&D) cabin
- dean_rd@cambridge.edu.in
- Preferred communication through whatspp

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Course info – As per VTU

COMPUTER VISION (Effective from the academic year 2018 -2019) SEMESTER – VII			
Subject Code	18AI742	**CIE Marks**	40
Number of Contact Hours/Week	3:0:0	**SEE Marks**	60
Total Number of Contact Hours	40	**Exam Hours**	3 Hrs
CREDITS – 03			

Syllabus - Module 1

Module – 1	Contact Hours
Introduction and Image Formation: What is computer vision? A brief history, Geometric primitives and transformations, Photometric image formation, The digital camera. Pinhole Perspective, Weak Perspective, Cameras with Lenses, The Human Eye, Intrinsic Parameters and Extrinsic Parameters, Geometric Camera Calibration **T1: Chap 1-1.1 & 1.2, Chap 2-2.1 to 2.3. T2:Chap 1-1.1 to 1.3**	08

Syllabus - Module 2

Module – 2	
Early Vision – One Image: Linear Filters and Convolution, Shift Invariant Linear Systems, Spatial Frequency and Fourier Transforms, Sampling and Aliasing, Filters as Templates, Local Image Features, Texture **T2:Chap 4-4.1 to 4.5, Chap5-5.1 to 5.5, Chap6-6.1 to 6.3, 6.5**	08

Syllabus - Module 3

Module – 3	
Early Vision – Multiple Images: Stereopsis and Structure from Motion **T2:Chap7-7.1 to 7.7, Chap 8-8.1 to 8.3**	08

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Syllabus - Module 4

Module – 4	
Mid-level Vision: Segmentation by Clustering, Grouping and Model fitting, Tracking **T2:Chap9-9.1 to 9.4, Chap 10-10.1 to 10.7, Chap 11-11.1 to 11.3**	08

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Syllabus - Module 5

Module – 5	
High-level Vision: Registration, Smooth Surface and their Outlines, Range Data Detecting Objects in Images, Recognition **T2:Chap12-12.1 to 12.3, Chap 13-13.1 to 13.3, Chap 14-14.1 to 14.4, Chap 17-17.1 to 17.3. T1:Chap 6-6.1 to 6.6**	08

Course outcomes

Course outcomes: The students should be able to:
• Implement fundamental image processing techniques required for computer vision • Understand Image formation process • Perform shape analysis • Develop applications using computer vision techniques • Understand video processing and motion computation

Question paper pattern

Question Paper Pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text and reference books

Textbooks:

1. Computer Vision: Algorithms and Applications (CVAA), Richard Szeliski, Springer, 2nd edition, 2020, http://szeliski.org/Book/
2. Computer Vision – A modern approach, by D. Forsyth and J. Ponce, Prentice Hall, 2nd edition, 2012

Reference Books:

1. R. C. Gonzalez, R. E. Woods. Digital Image Processing. Addison Wesley Longman, Inc., 1992.
2. D. H. Ballard, C. M. Brown. Computer Vision. Prentice-Hall, Englewood Cliffs, 1982.
3. Image Processing, Analysis, and Machine Vision. Sonka, Hlavac, and Boyle. Thomson.
4. Simon J. D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University, Press, 2012
5. Introductory Techniques for 3D Computer Vision, by E. Trucco and A. Verri, Publisher: Prentice Hall.
6. Building Computer Vision Applications Using Artificial Neural Networks - With Step-by-step Examples in OpencvAndTensorflow With Python, Shamshad Ansari,Apress, 2020

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$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \boldsymbol{j}_c$$

where

$$\nabla = \hat{\mathbf{i}}\frac{\partial}{\partial x} + \hat{\mathbf{j}}\frac{\partial}{\partial y} + \hat{\mathbf{k}}\frac{\partial}{\partial z}$$

CIE

- 2 tests – 30 marks
- All tutorial points – 10 marks
- Term paper 1 (optional)

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Definition of computer vision (CV)

Derivation of velocity of light from Maxwell's equations

$$\nabla \cdot \mathbf{E} = \rho/\varepsilon_0$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \boldsymbol{j}_c$$

where

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Derivation of velocity of light from Maxwell's equations

$$\nabla \cdot \mathbf{E} = \rho/\varepsilon_0$$ = 0 as $\rho = 0$ in vacuum

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \boldsymbol{j}_c$$ $J_c = 0$ in vacuum

where

$$\nabla = \hat{\mathbf{i}} \frac{\partial}{\partial x} + \hat{\mathbf{j}} \frac{\partial}{\partial y} + \hat{\mathbf{k}} \frac{\partial}{\partial z}$$

Derivation of velocity of light from Maxwell's equations

$$\nabla \cdot \mathbf{E} = 0$$

$$\nabla \cdot \mathbf{B} = 0$$

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where

$$\nabla = \hat{\mathbf{i}}\frac{\partial}{\partial x} + \hat{\mathbf{j}}\frac{\partial}{\partial y} + \hat{\mathbf{k}}\frac{\partial}{\partial z}$$

Derivation of velocity of light from Maxwell's equations

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad (1) \qquad\qquad \nabla . \mathbf{E} = 0 \qquad (2)$$

$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \qquad (3) \qquad\qquad \nabla . \mathbf{B} = 0 \qquad (4)$$

Derivation of velocity of light from Maxwell’s equations

To get a wave equation, we want second derivatives in both time and space.]

$$\nabla\times(\nabla\times\mathbf{E}) = -\frac{\partial(\nabla\times\mathbf{B})}{\partial t} = -\mu_0\varepsilon_0\frac{\partial^2}{\partial t^2}\mathbf{E}.$$

$$\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t} \qquad \nabla\times\mathbf{B} = \mu_0\varepsilon_0\frac{\partial\mathbf{E}}{\partial t}$$

Derivation of velocity of light from Maxwell's equations

A theorem in vector calculus is that, for any vector **a**,

$$\nabla\times(\nabla\times\mathbf{a}) = -\nabla^2\mathbf{a} + \nabla.(\nabla.\mathbf{a}).$$

Substituting a for E and $\nabla.\mathbf{E} = 0$

$$\nabla\times(\nabla\times\mathbf{E}) = -\frac{\partial(\nabla\times\mathbf{B})}{\partial t} = -\mu_0\varepsilon_0\frac{\partial^2}{\partial t^2}\mathbf{E}.$$

$$\nabla^2\mathbf{E} = \mu_0\varepsilon_0\frac{\partial^2}{\partial t^2}\mathbf{E}$$

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Derivation of velocity of light from Maxwell's equations

The wave equation in three dimensions to one dimension,

$$\nabla^2 \mathbf{E} = \mu_0 \varepsilon_0 \frac{\partial^2}{\partial t^2} \mathbf{E}$$

$$\frac{\partial^2 E}{\partial x^2} = \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2}$$

Derivation of velocity of light from Maxwell's equations

For a solution that is a sinusoidal wave, with speed v and wavelength λ.

$$E = E_0 \sin\left(2\pi \frac{x - vt}{\lambda}\right)$$

Differentiating, we get

$$\frac{\partial^2 E}{\partial^2 x} = -E_0 \left(\frac{2\pi}{\lambda}\right)^2 \sin\left(2\pi \frac{x - vt}{\lambda}\right)$$

Derivation of velocity of light from Maxwell's equations

For a solution that is a sinusoidal wave, with speed v and wavelength λ.

$$E = E_0 \sin\left(2\pi \frac{x - vt}{\lambda}\right)$$

Differentiating, we get

$$\frac{\partial^2 E}{\partial^2 x} = -E_0 \left(\frac{2\pi}{\lambda}\right)^2 \sin\left(2\pi \frac{x - vt}{\lambda}\right) \qquad \frac{\partial^2 E}{\partial^2 t} = -E_0 \left(\frac{2\pi v}{\lambda}\right)^2 \sin\left(2\pi \frac{x - vt}{\lambda}\right)$$

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Derivation of velocity of light from Maxwell's equations

$$\frac{\partial^2 E}{\partial x^2} = \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2}$$

$$\frac{\partial^2 E}{\partial^2 x} = -E_0\left(\frac{2\pi}{\lambda}\right)^2 \sin\left(2\pi\frac{x-vt}{\lambda}\right) \qquad \frac{\partial^2 E}{\partial^2 t} = -E_0\left(\frac{2\pi v}{\lambda}\right)^2 \sin\left(2\pi\frac{x-vt}{\lambda}\right)$$

Derivation of velocity of light from Maxwell's equations

$$v^2 = \frac{1}{\mu_0 \varepsilon_0}$$

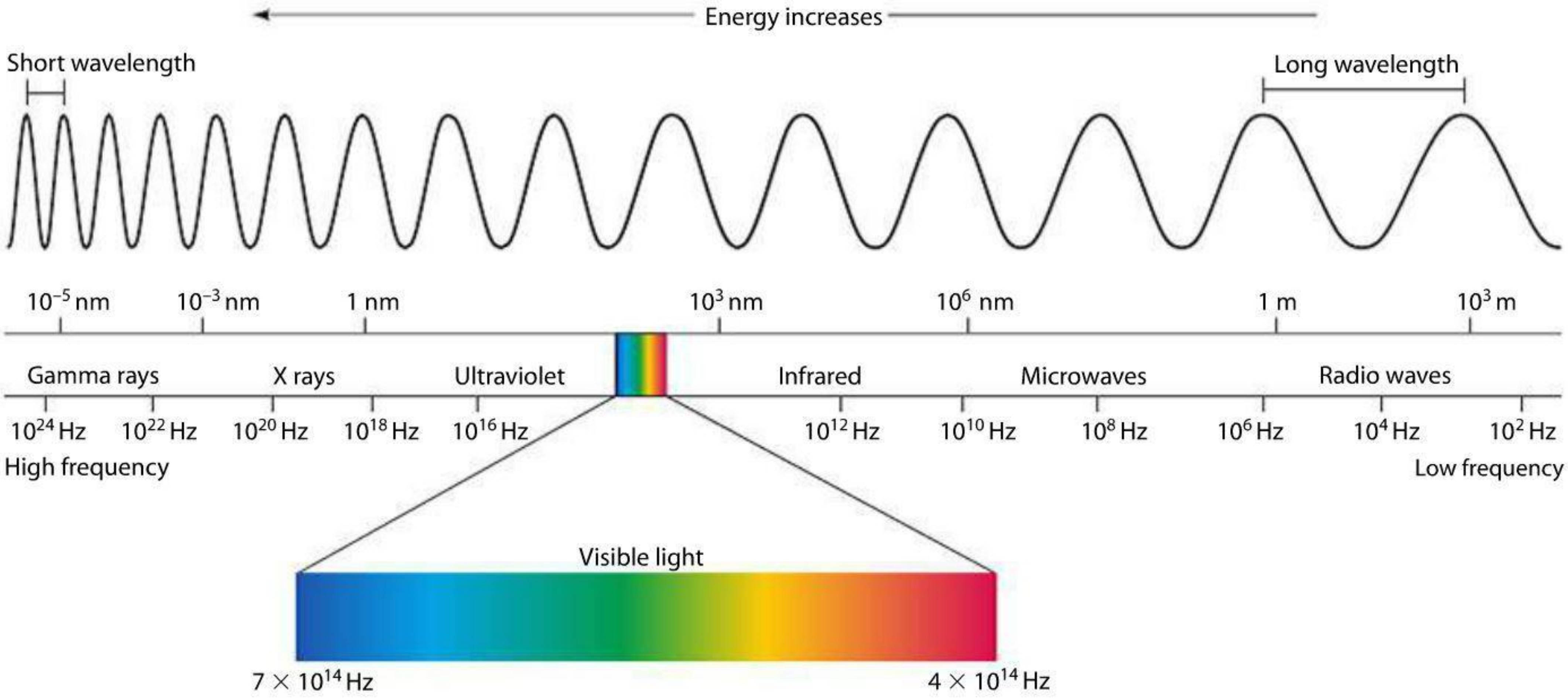
The value of permeability of free space = $1.25663706 \times 10^{-6}$ m kg s^{-2} A^{-2}

The value of permittivity of free space = $8.85418782 \times 10^{-12}$ m^{-3} kg^{-1} s^{4} A^{2}

The velocity of light = 299,792,458.130996 (calculation)

The velocity of light = 299,792,458 metres per second (theoretical)

Derivation of velocity of light from Maxwell's equations



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Major subdomains of CV

- Medical imaging
- Machine vision/ Industrial vision (Automobile industry)
- Security and surveillance (Biometrics and military)
- Assistive technology (Blind vision)
- Mobile robotics vision/drone vision

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Current trends in CV

- Real-Time Video Analytics
- AI Model Optimization
- Hardware AI Accelerator
- Edge Computer Vision
- Drone computing

Conclusion

Plethora of applicatcions of computer vision

- code
- test
- use

Q&A

Contact

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