Linescan camera

A linescan camera is a type of imaging device that captures images one line at a time, rather than capturing a full image all at once like traditional area scan cameras. These cameras are commonly used in industrial applications, particularly for high-speed and high-resolution imaging tasks where objects move continuously past the camera.

How Linescan Cameras Work: Single Line of Pixels: A linescan camera has a single row of pixels (e.g., 1024, 2048, or more pixels wide), and it captures one line of an image at a time as the object moves. Continuous Motion: To form a complete image, either the camera or the object being imaged must move continuously. The camera captures successive lines of pixels that are combined to create a 2D image. Synchronization: It is crucial to synchronize the movement speed with the camera's scan rate (the rate at which it captures lines) to ensure that the image is not distorted. Applications of Linescan Cameras: Industrial Inspection: Common in manufacturing for inspecting materials such as textiles, paper, glass, or metal surfaces for defects or quality control. Document Scanning: Used in high-speed document scanners to capture detailed images of large documents or surfaces. Food and Packaging Inspection: Applied in food processing industries to inspect products on a conveyor belt for defects, contaminants, or correct labeling. Print Inspection: Checks the quality of printed materials, such as newspapers, magazines, or packaging, at high speed. Scientific and Medical Imaging: Used in specialized research applications, like microscopy or satellite imaging, where precision and high resolution are required. Advantages of Linescan Cameras: High Resolution: Since the image is built line by line, they can achieve very high resolutions, especially when scanning long objects or surfaces. Speed: Linescan cameras can capture images at extremely high speeds because they do not need to process an entire frame at once. Continuous Imaging: Ideal for imaging objects in motion, such as products moving down a conveyor belt, where traditional area cameras may struggle with blur. Disadvantages: Requires Motion: Either the object or the camera must be moving to create an image, which makes them unsuitable for static scenes unless artificially moved. Synchronization Challenges: Any mismatch between the movement and the scan rate can lead to distorted images, requiring careful setup and control.

Hyperspectral imaging sensors have rapidly advanced, aiding in tumor diagnostics for in vivo brain tumors. Linescan cameras effectively distinguish between pathological and healthy tissue, whereas snapshot cameras offer a potential alternative to reduce acquisition time.

Aim: Our research compares linescan and snapshot hyperspectral cameras for in vivo brain tissues and chromophore identification.

Approach: We compared a linescan pushbroom camera and a snapshot camera using images from 10 patients with various pathologies. Objective comparisons were made using unnormalized and normalized data for healthy and pathological tissues. We utilized the interquartile range (IQR) for the spectral angle mapping (SAM), the goodness-of-fit coefficient (GFC), and the root mean square error (RMSE) within the 659.95 to 951.42 nm range. In addition, we assessed the ability of both cameras to capture tissue chromophores by analyzing absorbance from reflectance information.

Results: The SAM metric indicates reduced dispersion and high similarity between cameras for pathological samples, with a 9.68% IQR for normalized data compared with 2.38% for unnormalized data. This pattern is consistent across GFC and RMSE metrics, regardless of tissue type. Moreover, both cameras could identify absorption peaks of certain chromophores. For instance, using the absorbance measurements of the linescan camera, we obtained SAM values below 0.235 for four peaks, regardless of the tissue and type of data under inspection. These peaks are one for cytochrome b in its oxidized form at λ = 422 nm , two for HbO 2 at λ = 542 nm and λ = 576 nm , and one for water at λ = 976 nm .

Conclusion: The spectral signatures of the cameras show more similarity with unnormalized data, likely due to snapshot sensor noise, resulting in noisier signatures post-normalization. Comparisons in this study suggest that snapshot cameras might be viable alternatives to linescan cameras for real-time brain tissue identification [1).].

1)

Martín-Pérez A, Martinez de Ternero A, Lagares A, Juarez E, Sanz C. Spectral analysis comparison of pushbroom and snapshot hyperspectral cameras for in vivo brain tissues and chromophore identification. J Biomed Opt. 2024 Sep;29(9):093510. doi: 10.1117/1.JBO.29.9.093510. Epub 2024 Sep 24. PMID: 39318966; PMCID: PMC11420787.