GATED IMAGING

Vision solutions are spreading increasingly fast nowadays. Indeed, through enhanced technologies, people are able to see, discover, control and even secure their environment for extended capabilities. Vision solutions however must tackle various issues such as security, quality, efficiency, reliability … Multiple sectors are concerned and the needs are different. Thus vision products have to be compatible with many contexts: perceiving and detecting objects in severe conditions better than a Human being is one example that leads to new emerging technologies and techniques.

Thanks to research, field feedbacks and development, new products appear and push the boundaries of vision, one step further. Gated imaging is one of these developments: from laboratories to final integration, this innovation is building reliable solutions for new challenging applications.

VISION THROUGH OBSCURANTS

Active imaging is a specific technique for imaging a scene or an object. This technique is often used for improving the vision capability compared to passive imaging. The target is illuminated and the reflected light is collected on an imaging sensor.

In a pure medium, the incident light is reflected practically only by the targeted object. The quality of vision through the camera can be sufficient. However, if the medium of propagation is disturbed by what is called an “obscurant”, the incident light is not only reflected by the object, but also by the environment likely to return a proportion of the incident light on the sensor, called “backscattering effect”.

In such specific conditions, where the medium can be fog, heavy rain, dense smoke or even a snowstorm, the physical elements in the atmosphere can obstruct the light path and moreover, increase the backscattering. The final image is degraded by the disturbances due to the medium and by this backscattering effect. Indeed, the latter adds a disturbance signal over the target useful signal. The signal coming from the target is thus blurred by parasitic light..

Gated imaging is the solution to prevent this effect. The active illumination is here produced by a pulsed source, often a laser, which is controlled by an external user. The pulsed source is then synchronized with the sensor exposure time. The sensor is then able to integrate a specific segment of the reflected light (Fig1) and hence, taking into account the speed of light, to image a slice at a specific depth in a scene.

A user can choose to observe, for instance, only slices located at more than 1km from the camera. The observation will be satisfying because backscattering due to up-front particles will be removed, avoiding the *gray-out* effect.

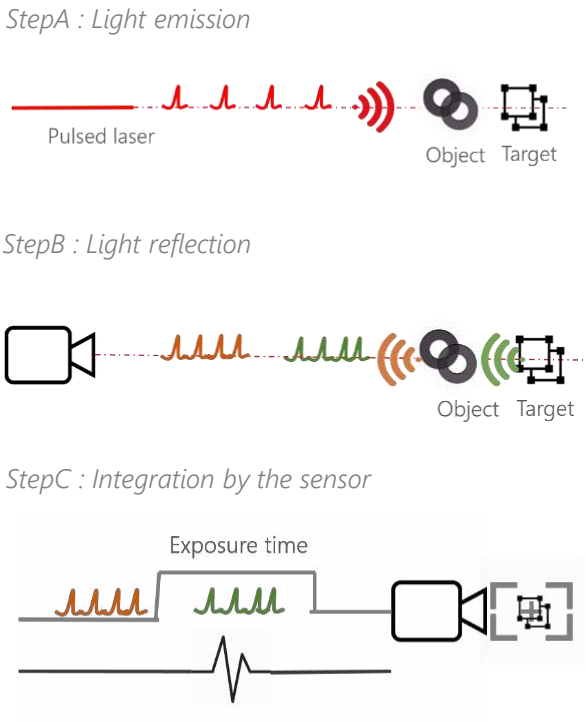


***Fig1** : Gated imaging principle*

A snowstorm illustrates this technique: instead of collecting all the rays reflected by each snowflake (Fig2), the camera is set up to record only the rays coming back at the distance of the targeted object (Fig3). The quality of the final image is then highly improved.

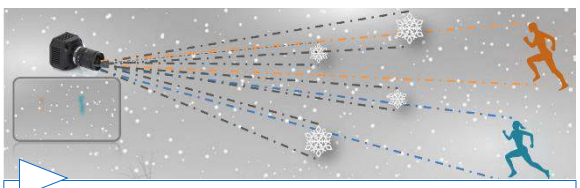


***Fig2** : Without gated imaging*

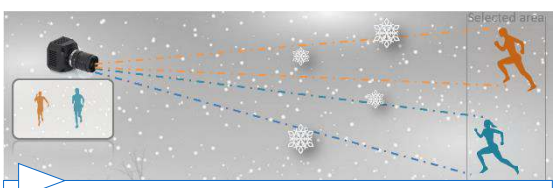


***Fig3** : With gated imaging*

For safety reason, these active observations must be achieved at an eye-safe wavelength, precisely 1,55 µm is known as "retina-safe" because human cornea and lens strongly absorb the wavelengths longer than 1,4 µm, avoiding the degradation of the retina. Besides, this wavelength guarantees a better transmission through atmosphere. The sensor has to be sensitive to this specific wavelength. Indium Gallium Arsenide (InGaAs) sensors - a very efficient semiconductor at room-temperature - are the most suited for this wavelength.

NEW IMAGING TECHNOLOGIES (NIT) has developed a complete portfolio of InGaAs sensors and cameras, the WiDy Cameras product line, optimized in terms of size, weight and power to perform in SWIR band. Some are specially designed to include a gated mode, encompassing all the specificities of active imaging.

Visible camera

Gated SWIR camera

Institut Saint Louis

Fig4 : *Imaging through smoke in maritime environment with ISL's 1,5µm system*

The performance of a SWIR camera to operate in gated mode is mainly defined by its ability to have the most defined slice of reflected light. This leads firstly to very short exposure times (30 cm covered in 1 ns by light). The patented pixel structure of NIT's sensors enables to offer an effective exposure time down to 100 ns whereas a traditional InGaAs sensor will be adequate for exposure times greater than 10 µs with a slow rise.

Shorter is the exposure time, narrower is the observed slice. With WiDy SWIR cameras, targets can be imaged in slices down to only 15m. Correlated with negligible sensitivity outside the exposure window, the region of interest is accurately delimited. This performance must be correlated with high quantum efficiency to have enough signal recorded by the sensor. The quality of images will lead to proper recognition and identification of targets.

TOMOGRAPHY

Controlling the delay between the trigger of the laser and the exposure time of the sensor allows customizing the observation of a scene. Users can choose their specific region of interest. By knowing the laser delay associated with an element of the detected scene, it is possible to determine the distance between this object and the camera.

VISIBLE

SWIR

This feature implies the need of accurate exposure delay control. The activation of the sensor is never immediate; it is more realistic to speak of an exposure window, with a rise and fall time.
Shorter is the rise time, more precise is the estimated distance. NIT's sensors provide a very short rise time of 20 ns and, combined with negligible sensitivity during time off, leads to a precision down to 3m.

With step by step delay increments, a three-dimensional map of the scene can be set up. Such tomographic reconstructions lead to quick localization of human constructions, vegetable obstacles and enemies' positions or any object in scenes distant from a few kilometers or closer to the camera. Field operations can be more easily prepared and lead.

Estimation of real distances is also challenging for safety issues, especially in emerging autonomous vehicles. By coupling it with a radar detection process, it can prevent collisions with obstacles.
By implementing it on vehicles or even drones, obstacle avoidance can be achieved, with a high reliability and all-weather conditions.

Slice at distance d1

Slice at distance d2

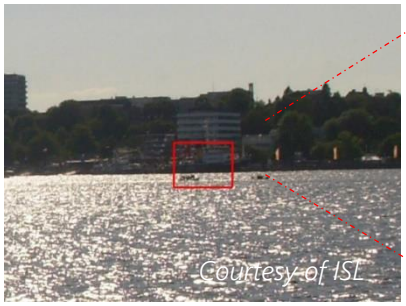
Slice at distance d3

GATED IMAGING

LONG-RANGE IMAGING

Active imaging is not only a concern for short-range vision but also for long-range vision. For the latter situation, very low quantities of light are integrated by the sensor so sensitivity – the lowest quantity of light that can be detected - is a crucial parameter. On the contrary, less precision is required. NIT offers a dual solution with a linear response for long-range observations and a logarithmic response for short-range vision. In this way, noise is reduced for long exposure time in order to increase sensitivity and succeed in imaging scenes located at higher distances from the camera.

In need of image quality improvement, continuous illumination can complete pulsed illumination. In this configuration, observation is guaranteed even when highly reflective surfaces are present thanks to NIT's High Dynamic Range Pixel technology, thus avoiding any saturation in observed scene.



Visible maritime scene

Gated imaging in SWIR band

GATED IMAGING provides the ability to image a specific depth slice of a scene. Applications are multiple, including observations through obscurants (severe weather conditions), estimation of distance and localization of obstacles. Imaging devices must be fast enough to cope with the reflected light. NIT's SWIR cameras offer at the same time precision with the shortest effective exposure time, the shortest rise time and highest dynamic range, enabling to cover a broad number of situations in the field, and any applications, including yours …