Clearing the Haze: Scientists design a way to see through fog

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In peering through a thick early morning mist or looking into a smoke-filled room or scanning muddy waters, we encounter a common problem – vision through such media gets obscured, and we cannot see what lies within. And many a times we have wanted to take pictures in foggy conditions, only to get a coarse image with no discernible features. 'Seeing' in these conditions would seem impossible without expensive equipments like thermal imaging cameras or radar technologies. The dream of that perfect picture on a foggy morning could be closer to reality, thanks to a new research. A collaborative study by scientists from Raman Research Institute (RRI), Bengaluru, and the University of Rennes, France are working to make seeing through the haze a reality.

When a human eye or camera lens 'sees' an object, most of the light reflected from the object go straight in to the eye or lens. When a scattering medium, like a gas or fluids, fills the space between the eye and the object, the object appears obscured. This happens because of tiny suspended particles present in such media that scatters the particles light in random directions. "To capture an image, the light rays should travel in straight lines, or should be deviated in a predictable way, as in a lens. However, if the light is scattered in unpredictable ways, only a diffused illumination with no recognisable image is obtained” remarks Prof. Hema Ramachandran of the Raman Research Institute, who led this research activity.

Scientists have been trying for decades to overcome this impediment, as the ability to image through turbid media has a wide range of applications. A few techniques have been developed that either require lasers that give out bursts of light of very short duration or uses cameras that have very short exposure times, both of which are very expensive. Cheaper alternatives usually require much longer data collection and processing times. For most applications, however, one would like to form images in real time, with little or no delay.

Scientists from RRI and the University of Rennes have together addressed this problem, and have developed a simple, inexpensive, yet powerful solution. They have successfully demonstrated, for the first time, instant, real time imaging through strongly scattering media simulating a quarter of a kilometre of fog. This was achieved without any sophisticated equipment like ultra-short pulsed lasers or ultrafast cameras. Using an inexpensive LED light source, ordinary scientific camera and by performing computations using a typical desktop computer, they have successfully obtained images within a few thousandths of a second after the camera records the diffuse illumination shots. The images refresh at rates faster than the eye can perceive, thus providing flicker-free real-time images of the scene obscured by strong scattering media.

The research sees many applications where visibility through murky conditions is of significant importance. Medical professionals, pilots, rescuers and even adventurers and photographers, require a clear sight in low-visibility conditions. “Such real-time imaging through strongly scattering media opens up innumerable possibilities for applications. Compact, low cost portable devices can be made, and used in many different areas. For example, aircraft landing under poor visibility, bio-medical imaging through flesh using ordinary light sources, rescue operations in smoke-filled environments are some areas that can utilise this development”, says Prof. Ramachandran.

“Realtime imaging through strongly scattering media was achieved by a combination of ideas. The scene was illuminated with light that was modulated in intensity. Due to the strong turbidity of the intervening medium, most of the photons undergo repeated random scattering. Because of this, the unprocessed camera shots show only uniform, diffuse illumination, with no discernible feature. We then applied the concept of quadrature lock-in detection to the problem of distinguishing photons that have not been deviated from their original trajectories from the photons that have been randomly scattered” explains Prof. Ramachandran.

“Conventionally, scientists use the Fourier transform technique, where one takes a time series and finds out the strength of contribution at each frequency over a certain range, and then picks out the dominant frequency. Here, as we know the source modulation frequency, a lot of computation time can be saved by looking at just that one frequency. Not only that, unlike Fourier transform, where data has to be recorded for a length of time before the Fourier transform can be applied, in our approach, we can start the processing as soon as the first shot of diffused illumination is captured. This too is an enormous saving on time. Last, but not the least, we have utilised the wonderful parallel processing capabilities that even a typical desktop computer has. Using the Graphics Processing Unit (GPU) of the computer, we have carried out the computations for each pixel of the image in parallel. All these ideas put together have enabled more than a thousand-fold increase in imaging speed, that has enabled the instant extraction of the hidden scene”, she explains. She goes on to say “Computers these days have very good GPU’s. Especially the ones used for gaming can already perform multiple tasks simultaneously. We have just utilized this data processing ability of the modern GPU along with our algorithm to successfully see through turbid medium. QLD is easily amenable to speed up on GPUs as compared to FFT”. Thus, by combining the strengths of the new algorithm - QLD, with currently available technology, the researchers have been able to cut down the data processing time by a significant margin. This allows them to capture an image in real time.

Technology today does allow us to see in a cloudy atmosphere with the help of infrared, x-ray and other imaging devices. But, apart from being expensive and often bulky, to be able to see features and details in an image, a camera that captures visible light would have to be used. The proposed new technique would progress the field of medicine, navigation, climate sciences and even space exploration by just recording clearer images and videos even in turbid conditions.

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