New Indian Innovation Captures Explosive Events Like Never Before: A Breakthrough for Defense and Industry

In a significant stride towards innovation in high-speed imaging, researchers at IIT Indore, led by Prof. Devendra Deshmukh, have developed a groundbreaking technique in collaboration with the Defence Research and Development Organisation (DRDO). This new method promises to transform the way we visualize and understand explosive events, making it a game-changer in fields like aerospace, defence, and industry.

Imaging fast-moving particles during explosive events has long been a challenge for scientists. Traditional techniques, such as Shadowgraphy, Schlieren, and X-ray imaging, offers a minimum exposure time of only about 1 microsecond—to capture images. This is a very-high exposure time (as compared to the speed of the phenomena) and often results in blurred images resulting in loss of details, leaving researchers with incomplete information of high-speed phenomena. Yet, understanding the behavior of these fast-moving objects and phenomena is critical, especially in sectors where safety and precision are paramount, such as defense and aerospace.

To address this challenge, Prof. Deshmukh and his team have developed a novel imaging method using the principles of Digital Inline Holography. This approach allows for a much sharper and more detailed visualization of objects even in dust or combustion cloud, something that was previously difficult to achieve. The captured images not only provide clear picture to the researchers, but also make it possible to accurately extract a wealth of information about the objects' velocity, acceleration, and distribution in space. This level of detail is essential for researchers who need to understand not just where the objects are, but how they move and behave in the chaotic aftermath of an explosion.

At the core of this innovation is a high-frequency (HF) light source. This particular light source has been specifically chosen for its ability to penetrate the dense dust clouds. By incorporating the high-speed laser in the optics setup for illumination, Prof. Deshmukh's team has overcome one of the biggest limitations of previous methods: poor visibility in obscured environments. Now, even in the midst of dust and fire, the system can capture crisp, clear images of high-speed particles in motion.

What makes this method truly stand out is its ability to significantly enhance time resolution. While conventional methods were limited to 1 microsecond exposure times, this new technique can capture images with exposure times as low as 50 nanoseconds. The system is capable of recording up to 700,000 frames per second, giving researchers a real-time look at how particles behave during an explosion. This dramatic increase in time resolution allows for far more detailed tracking of fast-moving objects, even in environments filled with dust, smoke, or other visual obstructions.

The laser light system has adjustable pulse widths starting from as low as 10 nanoseconds. This flexibility allows researchers to adapt the system to various experimental setups, making it versatile enough for a wide range of high-speed

events. Whether the task is studying the dynamics of a detonation or analyzing the impact of high-speed particles on materials, this technique provides a level of detail and accuracy that was previously unattainable.

The implications of this breakthrough extend far beyond the laboratory. In defense research, for example, the ability to clearly visualize and analyze the behavior of fragments after an explosion can lead to improvements in both offensive and defensive technologies. By understanding how fragments move and disperse, researchers can design more effective explosive devices, while also developing better protective measures for personnel and equipment. One of the most promising applications is in the study of detonation gas clouds, which often obscure critical details about the behavior of fragments immediately after an explosion. With this new technique, scientists can see through the cloud to gain insights that were previously hidden from view.

This breakthrough is equally valuable to the aerospace industry, where high-speed imaging is essential for studying everything from fuel spray patterns to the impact of debris on spacecraft. The ability to capture these events in real-time and with exceptional clarity allows engineers to design safer and more efficient systems. For example, understanding how particles behave during a high-velocity impact can lead to innovations in material design that better protect against collisions in space or during flight.

In industrial applications, the technique can be used to analyze very high-speed processes like material cutting, spray formation, and fluid dynamics in manufacturing settings. The insights gained from such studies could lead to more efficient processes and higher-quality products, further demonstrating the versatility and far-reaching impact of this technology.

Moreover, this development represents a major step forward in India's push towards self-reliance in critical technologies. By developing this high-speed imaging technique domestically, the collaboration between IIT Indore and DRDO supports the Atmanirbhar Bharat initiative, which aims to reduce the country's reliance on foreign technologies. The filing of a patent for this innovative system highlights the importance of homegrown solutions in addressing national security needs and advancing scientific research.

The journey doesn't end here. Prof. Deshmukh's team continues to push the boundaries of what is possible in high-speed imaging. Their ongoing research aims to further refine the technique, with the goal of capturing even faster-moving objects. In the near future, they hope to achieve recording rates of over a million frames per second, opening up new possibilities for studying ultra-fast phenomena.

This remarkable collaboration between IIT Indore and DRDO has not only solved a longstanding problem in high-speed imaging but has also set the stage for future advancements in both defense and scientific research. As this technology continues to evolve, it will undoubtedly lead to safer, more efficient systems across a variety of sectors, from national security to aerospace and beyond.

For industries interested in commercializing this innovative technology, they are available through IIT Indore. The institute is actively seeking partnerships and collaborations to bring these technologies to market. Interested parties are

encouraged to contact on the *eo-ctr@iiti.ac.in* for more information on licensing and collaboration opportunities.

Note: You are requested to mention the mail id (*eo-ctr@iiti.ac.in)* to reach out to us for Technology Transfer and Commercialization.