

Abstract/Executive Summary



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1. **Title of the Project:** Real-time Image Enhancement: Rain and Fog Removal from Video
2. **Date of Start of the Project:** 1st April 2018
3. **Aims and Objectives:** Real-Time Image Enhancement: Rain and Fog Removal from Videos with software/technology development and Field Trials on development of the following (i) Embedded rain and fog removal software solutions with appropriate interface, (ii) Algorithms beneficial to ADAS (Advanced Driver Assistance Systems) to improve the safety in various transportation systems, as well as various security applications and outdoor video coverage.
4. Significant achievements (not more than 500 words to include List of patents, publications, prototype, deployment etc)
 - A. **Patents**
 1. Abhishek Kumar Tripathi, Sudipta Mukhopadhyay, "Method and apparatus for detection and removal of rain from video using temporal and spatiotemporal properties," Patent application No: 1284/KOL/2010 dated 15-Nov-2010, PCT application no. PCT/IN2011/000778 dated 11-Nov-2011 (granted in India, WTO filing approved),
 2. Sudipta Mukhopadhyay, Abhishek Kr. Tripathi, "Method and systems for removal of fog from the images and videos", US Patent: US20140140619A1 patent granted on 24th November 2015.
 3. Sudipta Mukhopadhyay, Abhishek Kr. Tripathi, "Method and systems for removal of fog from the images and videos", European Patent: EP2740100A1 patent granted on 11th June 2014.
 4. Sudipta Mukhopadhyay, Abhishek Kr. Tripathi, "Method and systems for removal of fog from the images and videos", Korean Patent: KR101568971B1 patent granted on 13th November 2015.

5. Abhishek Kumar Tripathi, Sudipta Mukhopadhyay, "Method and apparatus for detection and removal of rain from video using temporal and spatiotemporal properties," US Patent No: US9077869B2 granted on 07-July-2015
6. Abhishek Kumar Tripathi, Sudipta Mukhopadhyay, "Method and apparatus for detection and removal of rain from video using temporal and spatiotemporal properties," European Patent No: EP2641230B1 granted on 06-September-2017.
7. Abhishek Kumar Tripathi, Sudipta Mukhopadhyay, "Method and apparatus for detection and removal of rain from video using temporal and spatiotemporal properties," Korean Patent No: KR101591576B1 granted on 03-February-2016.
8. Sudipta Mukhopadhyay, Abhishek Kr. Tripathi, "Method and systems for removal of fog from the images and videos", Patent Application: 1029/KOL/2011 dated 03-Aug-2011, PCT filing No. PCT/IN2012/000077 dated 02-02-2012 (under evaluation in India, WTO filing approved)

Invention Disclosure:

1. Sudipta Mukhopadhyay, Bijaylaxmi Das, "A Haze Removal Technique from A Single Image with Color Correction" is rated for filing.

B. Publications

Book:

1. Sudipta Mukhopadhyay and Abhishek Kumar Tripathi, "Combating Bad Weather Part I: Rain Removal from Video", Morgan & Claypool Publishers (1st January 2015)
2. Sudipta Mukhopadhyay and Abhishek Kumar Tripathi, "Combating Bad Weather Part II: Fog Removal from Image and Video", Morgan & Claypool Publishers (1st January 2015)

Journal:

1. Bijaylaxmi Das, Joshua Peter Ebenezer, Sudipta Mukhopadhyay, "A comparative study of single image fog removal methods," accepted in The Visual Computer Page 5 of 20 (Springer Journal), Oct 2020 <https://doi.org/10.1007/s00371-020-02010-4> (Cited by 1, Impact Factor 1.456 in 2019)
2. A. K. Tripathi and S. Mukhopadhyay, "Efficient fog removal from video", Signal Image and Video Processing (Springer), published online, pp 1-9, Thu, 14th September 2012, DOI: 10.1007/s11760-012-0377-2 (Cited by 9, Impact factor 1.794)
3. A. K. Tripathi and S. Mukhopadhyay, "Single Image Fog Removal Using Anisotropic Diffusion", IET Image processing, Volume 6, issue7, pp. 966 – 975, October 2012, (Cited by 98, Impact factor 1.98)
4. A. K. Tripathi and S. Mukhopadhyay, "Removal of rain from videos: A review," Signal Image and Video Processing (Springer), online September 2012, pp 1421– 1430, Volume 8, Issue 8, November 2014. (Cited by 80, Impact factor 1.794 in 2019)
5. A. K. Tripathi and S. Mukhopadhyay, "Removal of fog from images: A review," IETE Technical Review., pp 148 -156, vol. 29, Issue 2, March-April, 2012 (Cited by 49, Impact factor 1.845)
6. A. K. Tripathi and S. Mukhopadhyay, "Video Post Processing: Low Latency Spatiotemporal Approach for Detection and Removal of Rain," IET Image Processing Vol. 6, No. 2, pp. 181-196, 2012 (Cited by 54, Impact factor 1.98)
- Abhishek Kumar Tripathi, Sudipta Mukhopadhyay "A Probabilistic Approach for Detection and Removal of Rain from Videos" IETE Journal of Research, Pages:82-91, Issue No. 1, Volume: 57, Jan-Feb 2011. (Cited by 48, Impact factor 1.125)

C. Conference:

1. Joshua Peter Ebenezer, Bijaylaxmi Das, and Sudipta Mukhopadhyay, "Single Image Haze Removal Using Conditional Wasserstein Generative Adversarial Networks", 27th

European Signal Processing Conference, A Coruna, Spain, September 2-6, 2019. (Cited by 8)

2. A. K. Tripathi, S. Mukhopadhyay, "Single Image Fog Removal Using Bilateral Filter," IEEE International Conference on Signal Processing, Computing and Control 2012, Jaypee University of Information Technology, Wanknaghat, India, 15-18th March 2012 (Cited by 73)

3. A. K. Tripathi and S. Mukhopadhyay, "Rain Rendering in Videos", 4th International Conference On Computer Applications in Electrical Engineering Recent Advances, IIT Roorkee, India, Feb. 2010. (Cited by 4)

Highlights.

- a. Our startup named **Proficient Vision Solutions Private Limited** has received National Award for Technology Startup from Technology Development Board in 2021.
- b. Our start-up received **CII Statrtupreneur Award, 2019.**
- c. Our research work "Real-time Fog Removal from Video and Rain Removal from Video" received **FICCI R&D Awards 2017 under GLOBAL R&D SUMMIT 2017 on April 6-7, 2017** at The Lalit Ashok, Kumara Krupa High Grounds, Bengaluru, India.
- d. Our research "On glass visualization in real-time: Rain removal from videos" received a position among the top nine innovations in "University Challenge of IIGP2.0 2017".
- e. "Real-Time Fog Removal from Video in Application to Safety and Surveillance" ranked 5th in the List of Top 50 Innovators in the 2016 DST - Lockheed Martin India Innovation Growth Programme

Prototype

- a. A standalone desktop solution is ready for demonstration and use.
- b. We are working on a client-server model which will be very useful for camera based surveillance. Soon it will be ready for demonstration and use.
- c. We have also a demonstration setup ready on Single board computer for mobility solutions.

5. Concluding remarks: We believe in our tagline '*Better safe than never*'!

We are looking for partners who will help us in field trial (paid proof of concept) and reach the market.