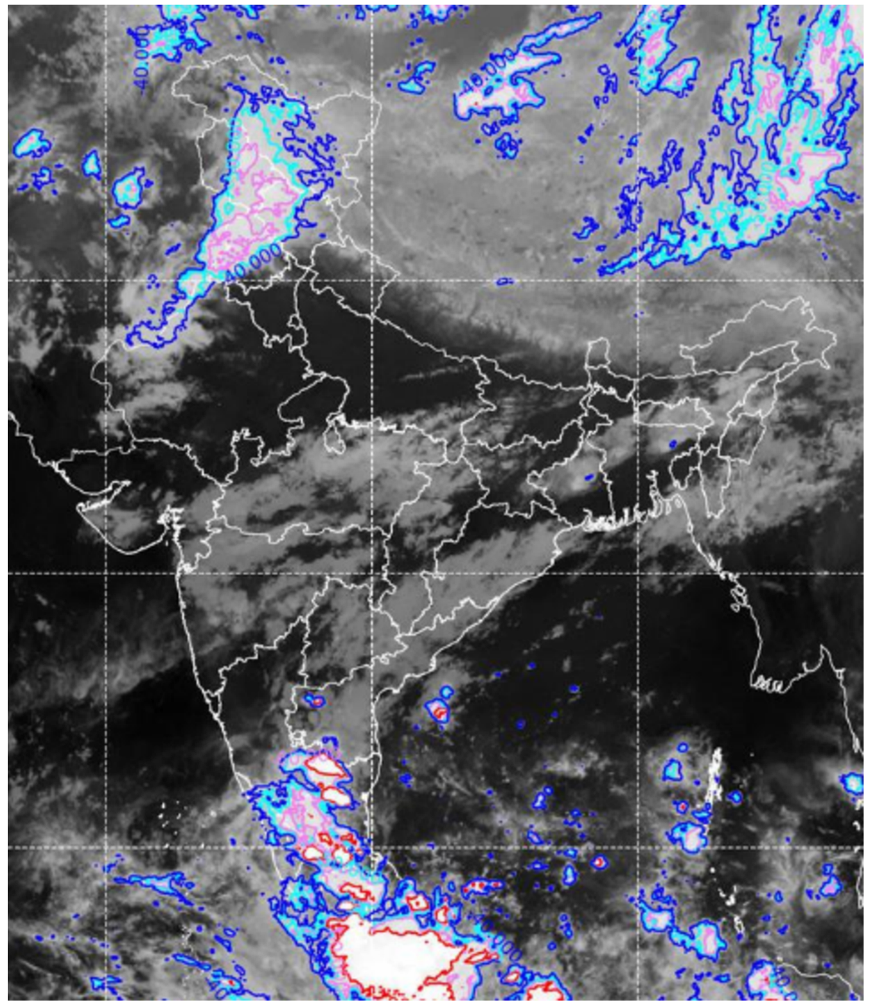
SMART INDIA HACKATHON 2024

VORTEX VISION

- **Problem Statement ID – 1736**
- **Problem Statement Title - AI based frame interpolation, video generation and display system for WMS services**
- **Theme- Smart Automation**
- **PS Category- Software**
- **Team ID - AVV-CBE-38**
- **Team Name - CrewX**



AI Based Frame Interpolation for WMS

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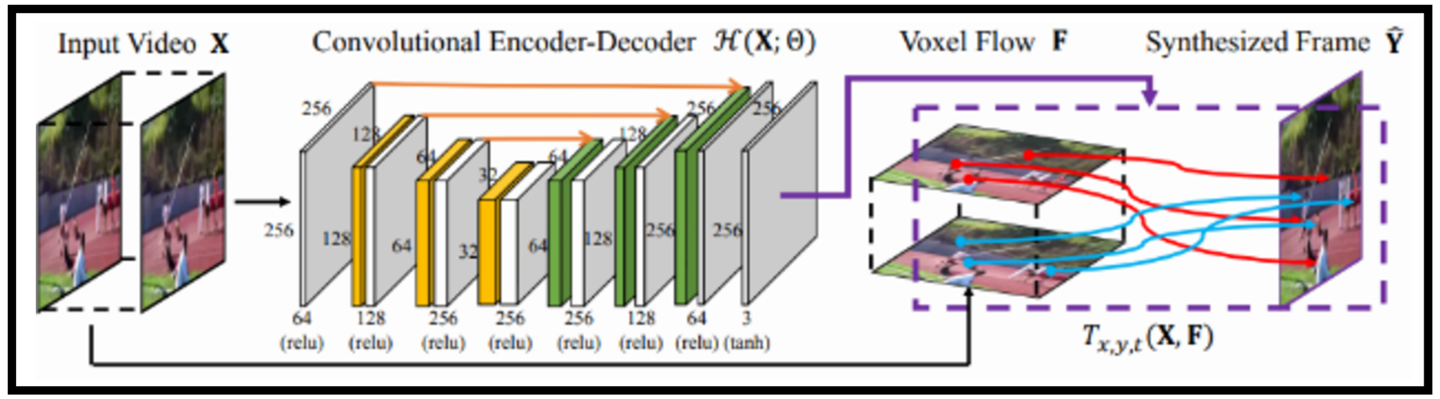
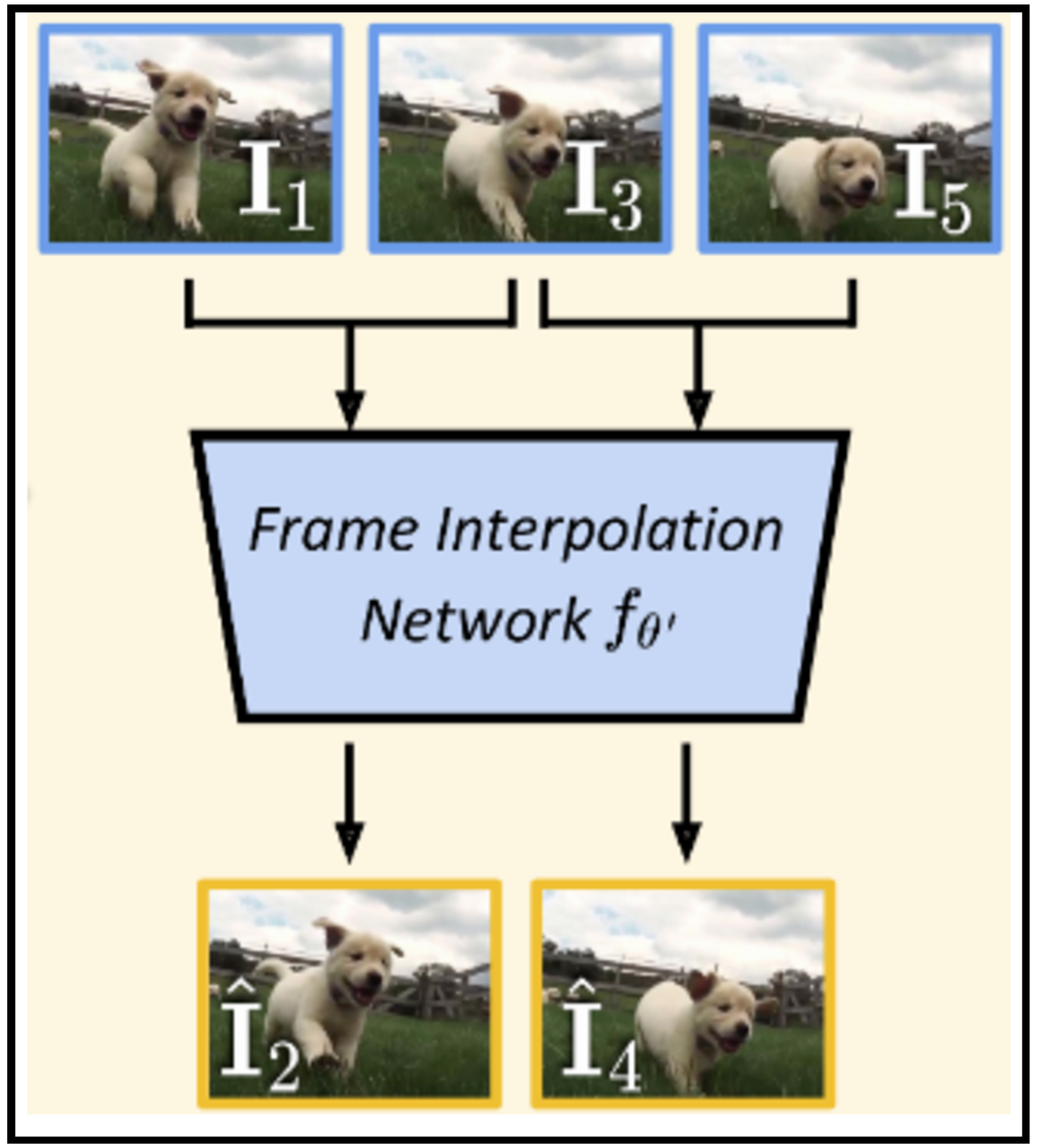
Proposed Solution

Preliminary work:

Idea:



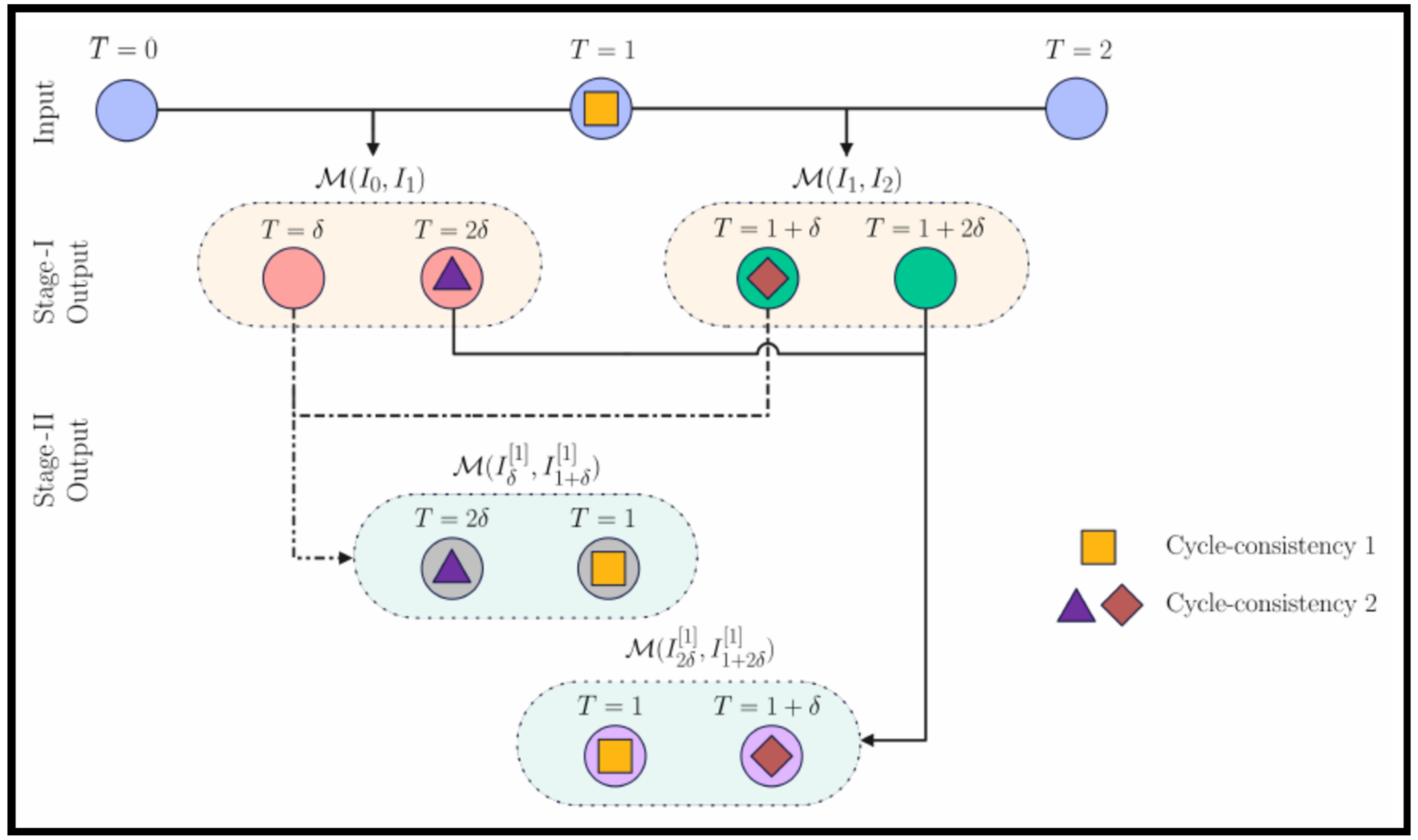
- **Input:** Three consecutive satellite images **(F0, F3, F6)** which is the only data available.
- **Dual Cycle Consistency**:
-   – **Cycle 1**: Forward pass through the network producing **(F1, F2)** and **(F4, F5)**.
-   – **Cycle 2**: Interpolation between **(F1, F4)** & **(F2, F5)** producing **(F2,F3)** & **(F3,F4)** respectively.
- Now, we employ a loss to ensure that **F2, F3 & F4** doesn't change over **different cycles**.
- **Recursion**: After generation, we recursively pass the generated frames until we produce frames with a minute interval **(3 levels of recursion)**.
- **Super Resolution**: Super resolution via **deep diffusion models** to enhance the spatial resolution and detail of meteorological data.
- **Visualization:** Develop a backend server to **serve geospatial-temporal video** content, and create an OpenLayers-based web interface with **synchronized video** overlays and **optimized streaming**.

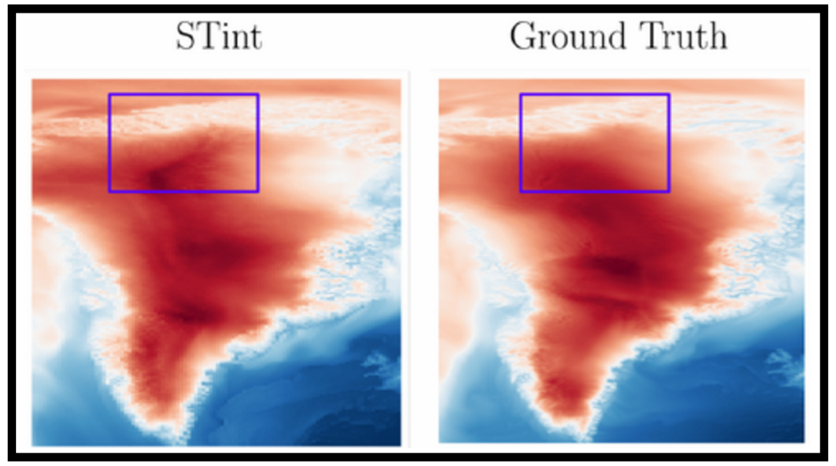


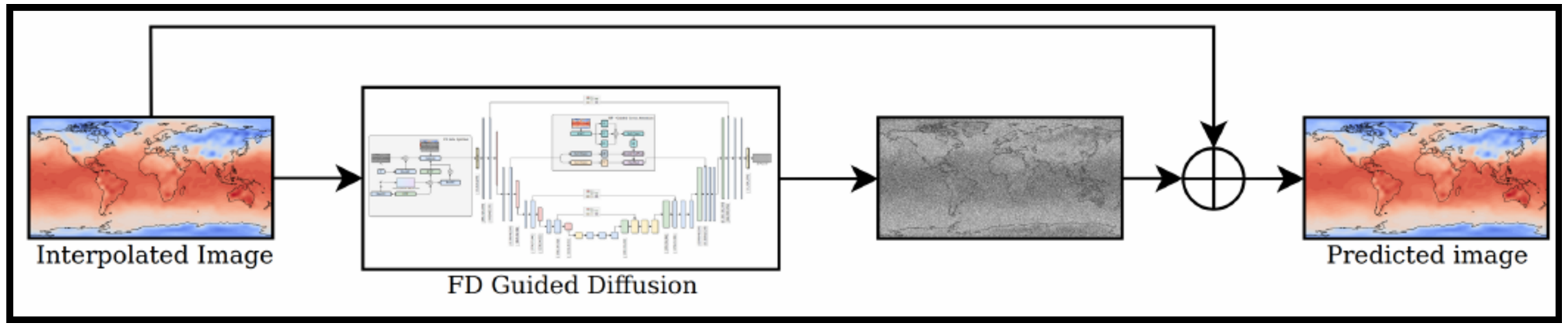
Innovation:

- **Self Supervised:** There is **no need for ground truth** masks which **reduces the cost** of obtaining data.
- Conversion from a 30 minute interval to a minute interval ensures **smooth visualization**.
- Handles **disappearance of objects** like clouds.
- **Super resolution** ensures that the frames generated is **not of low quality**, which is inevitable in multiple interpolations from the generated images.
- **On device implementation:** The network uses **on device CPU/GPU** for frame interpolation.

TECHNICAL APPROACH







I. Data Acquisition & Preprocessing

Integrate with WMS service to download satellite imagery and preprocess them.

II. Frame Interpolation (STint)

Self supervised architecture with no need for ground truth masks, using on-device CPUs/GPUs.

III. Super Resolution

Generate higher quality images using deep diffusion models from interpolated frames.

IV. Video Generation System

Encode the interpolated frames to generate a video for visualization.

V. Web-based Display System

Overlaying videos on web based map visualization for modern open source wegis libraries with controls using leaflet as a base.

VI. Web Hosting

Hosting in government sites such as MODSAC for use by WebGIS developers.

VII. Application deployment

FEASIBILITY AND VIABILITY

- Analysis of the feasibility of the idea:
  - Using **advanced models** like Stint and Deep Diffusion models leverages **proven technology** and **cuts costs** for recording ground truth images.
  - Interactive video visualization with **map overlay** and controls using open source libraries such as **leaflet** ensures proper visualization of **interpolated frames**.

- Potential challenges and risks:
  - Frame interpolation of objects such as clouds which are **deformable** and even appear disappear between frames.
  - Utilization of **on-device CPUs/GPUs** poses a problem as most of the devices are **limited in potential**.

- Strategies for overcoming these challenges:
  - The **self-supervised architecture** ensures the proper **removal of deformable objects** in-between frames.
  - Using **model distillation or pruning techniques** can significantly reduce the number of parameters, thereby lowering the forward/backward pass cost, making the model **more feasible** for implementation on **on-device CPUs/GPUs**.

IMPACT AND BENEFITS

- Potential impact on the target audience:
  - **Enhanced Meteorological Monitoring:** Accurate, high-resolution satellite video streams at shorter time intervals provide meteorologists with better situational awareness.
  - **Efficiency for Agricultural Planning:** The ability to visualize satellite imagery with fine temporal resolution can help farmers monitor weather patterns and plan crops.
  - **Better Visualization for Laymen:** Instead of raw, static images taken at long intervals, generated smooth & continuous videos are easier for non-experts to grasp.

- Benefits of the solution (social, economic, environmental, etc.)
  - **Environmental Monitoring:** The system can help track climate change impacts and natural disasters in greater detail, supporting long term sustainability.
  - **Social Impact:** Accurate satellite visualizations can enhance public safety by providing timely information about potential natural disasters.
  - **Economic Efficiency:** By reducing the need for expensive data acquisition (by avoiding sampling images at a higher resolution), it lowers the operational costs for meteorological and environmental agencies while still providing high-quality results.

RESEARCH AND REFERENCES

1) Harilal, N., Hodge, B. M., Subramanian, A., & Monteleoni, C. (2023). **STint: Self-supervised Temporal Interpolation for Geospatial Data**. arXiv preprint arXiv:2309.00059.

2) Martinů, J. M., & Šimánek, P. (2024, September). **Enhancing Weather Predictions: Super-Resolution via Deep Diffusion Models**. In International Conference on Artificial Neural Networks (pp. 186-197). Cham: Springer Nature Switzerland.

3) Çiçek, Ö., Abdulkadir, A., Lienkamp, S. S., Brox, T., & Ronneberger, O. (2016). **3D U-Net**: learning dense volumetric segmentation from sparse annotation. In Medical Image Computing and Computer-Assisted Intervention−MICCAI 2016: 19th International Conference, Athens, Greece, October 17-21, 2016, Proceedings, Part II 19 (pp. 424-432). Springer International Publishing.

4) Sen12ms dataset - https://dataserv.ub.tum.de/s/m1474000?dir=undefined&openfile=8187342