Predicting Short-Term Solar Variability: Integrating Irradiance Measurements with Sky Observations

SOLAR WINTER SCHOOL

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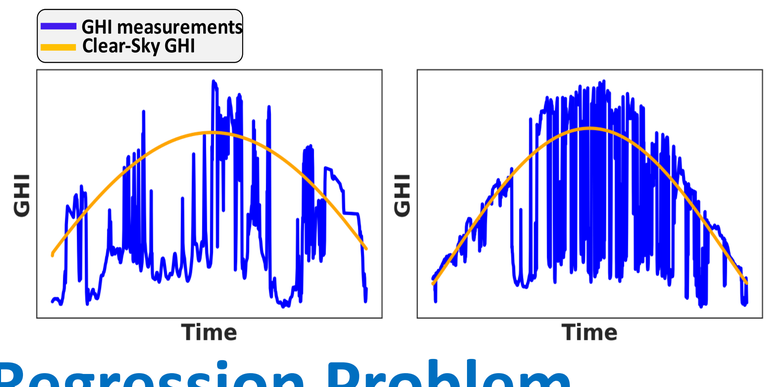
Why Predicting Solar Variability Is Important and Complex?

Our research focuses on the imperative of accurately forecasting short-term solar irradiance to optimize hybrid power systems and reduce operational expenses in the energy sector. Challenges in forecasting arise from:

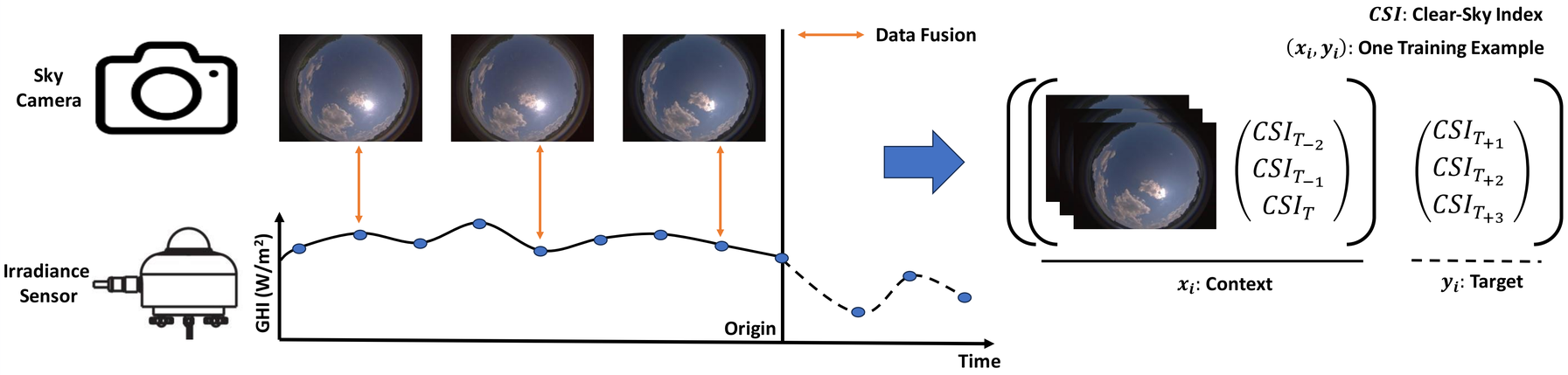
- Atmospheric dynamics' non-stationary nature, causing abrupt solar energy fluctuations that are difficult to anticipate,
- Insufficient prior physical knowledge of critical variables like wind speed and cloud layers.

These challenges highlight the need for advanced models that merge irradiance data with sky observations for precise solar forecasts.



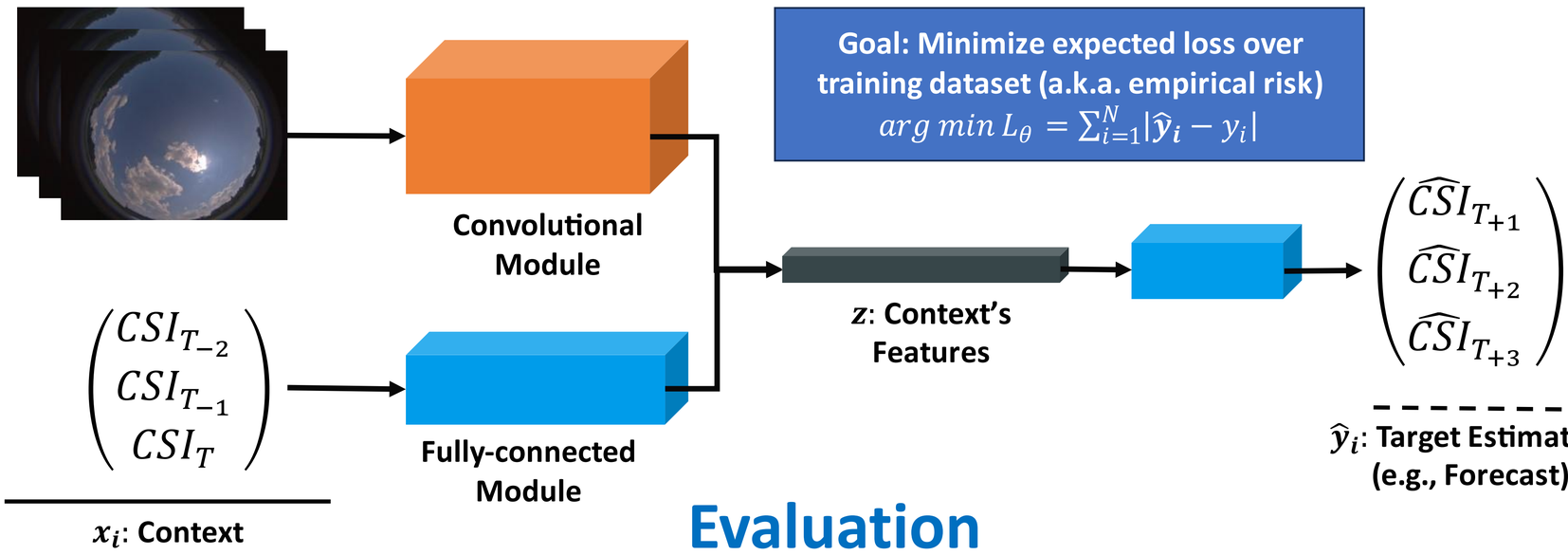
Forecasting: A Supervised Regression Problem

The task is to predict a continuous target value $y \in Y = R^K$ for any given input $x \in X$. To solve this, we are also given a training set of input-target pairs, $D = \{(x_i, y_i)\}_{i=1}^{N} \sim p(x, y)$. The nature and dimension of X and Y generally vary according to the application.



Neural Network Modeling

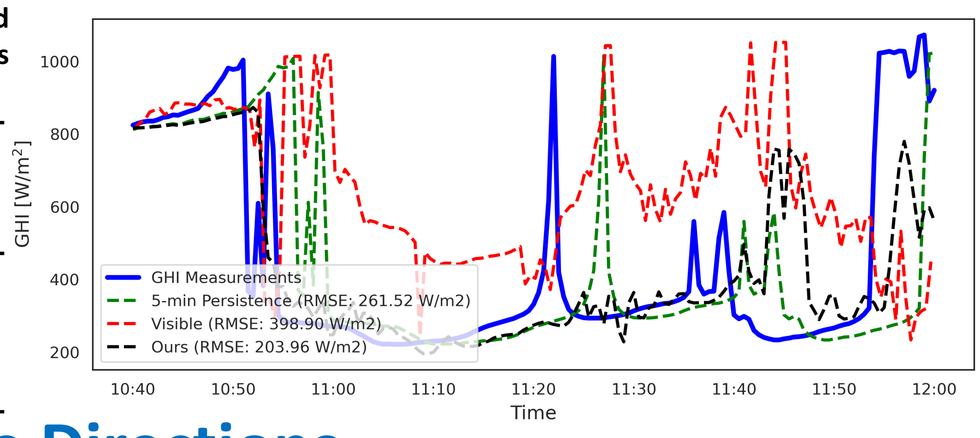
We model the relationship between the target and input variables using a neural network, parameterized to optimize the training objective through end-to-end weight adjustments.



Evaluation

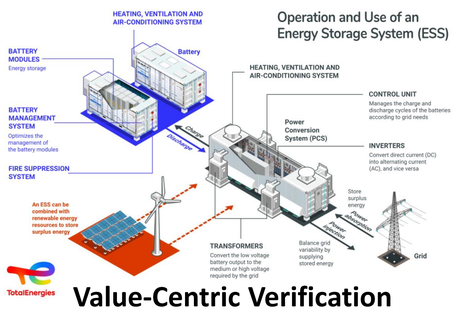
Our approach is evaluated against existing baselines and commercial forecasting solutions. This comparison encompasses a variety of technologies, including visible and infrared imaging.

	Testing Set A (3 months)			Testing Set B (5 months)		
Metric	RMSE [W m^{-2}]	nRMSE [%]	Skill-Score [%]	RMSE	nRMSE	Skill-Score
Commercial (Visible)	141.19	36.14	−16.90	N/A	N/A	N/A
Commercial (IR)	N/A	N/A	N/A	88.78	35.59	−6.80
Ours	77.09	23.22	15.05	34.74	25.28	16.15



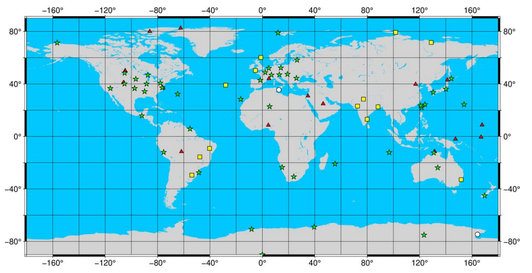
Future Directions

Building on this project's findings, we outline a Ph.D. project titled ***"Hybrid Intra-hour Solar Irradiance Forecasting: An Integrated Approach with Sky and Satellite Images"***. This project aims to develop a comprehensive forecasting framework that employs a value-centric verification approach, capable of integrating various data sources and general across different climatic conditions.



Value-Centric Verification

Unified Approach



Geographically Flexible

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