

# **Design & optimization of AI-Integrated Devices using Physics Tools: A Review**

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## **Abstract:**

The integration of Artificial Intelligence (AI) with physics tools has emerged as a transformative approach in science and engineering. As industries demand faster, more efficient, and cost-effective solutions, traditional physics tools are often limited by high computational costs, long simulation times, and the complexity of solving coupled multi-physics phenomena. AI-based optimization overcome these challenges by enhancing predictive accuracy, accelerating simulation model and enabling real-time design iteration across a range of dynamics applications. Recent advances have focused on the use of supervised learning algorithms, particularly deep learning, design model, and reinforcement learning, to approximate complexity .

This paper reviews current advancements in AI-integrated devices using physics tools in energy systems, and biomedical device design and so on. It also identifies limitations in current methodologies, including data science , design of model and integration complexity. The future of AI in this domain lies in the convergence of explainable AI, edge computing, and autonomous simulation systems. In summary, the trend of advanced AI sensors is the complementary between edge computing and cloud computing, which will show great potential in the applications of smart buildings, individual healthcare, the Internet of things through supervised learning.

**Keywords:** Artificial Intelligence , Physics tools ,Optimization , sensors

## 1. INTRODUCTION

The increasing complexity of AI implemented sensor device configuration challenges in achieving to optimize Power, Performance, and Area (PPA) accelerating design . Traditional approaches to design often involve manual or heuristic-driven processes, which are time-consuming and may not fully exploit optimization opportunities. This paper explores & review the application of Artificial Intelligence (AI) in automating and improving various stages of the design of physics based models by leveraging supervised learning algorithms, AI is implemented to achieve optimized PPA goals, accelerating the design cycle, and enhancing system performance including floor planning, placement, routing, standard cell design, and grid optimization in the context of AI-driven techniques. AI can reduce design iterations, enhance performance, and minimize power consumption.

## 2. Overview of Physical sensor Design through AI

A design process AI-Integrated device consists of multiple stages, each focusing on transforming characteristics of a high-level sensors into AI layout. The key stages of the physics tool design process are outlined below:

- **Partitioning:** Dividing the circuit into smaller blocks to make the design process more manageable.
- **Floor planning:** Determining the relative positions of the blocks and the allocation of routing resources.
- **Placement:** Deciding the exact positions of individual cells within the blocks, while considering timing, area, and power constraints.
- **Routing:** Establishing the physical connections between placed cells while minimizing wavelength and bandwidth by ensuring signal integrity.
- **Clock Tree Synthesis (CTS):** Building a balanced tree to distribute the clock signal uniformly across the chip.
- **Timing Closure:** Ensuring that all timing constraints are satisfied after placement and routing.
- **Design Rule Checking (DRC):** Each stage of the design introduces optimization challenges that can be enhanced through AI techniques.

### 3. OPTIMIZATION OF AI SENSORS

AI techniques optimize leakage and dynamic power in standard cells by tweaking transistor stacking and implementing techniques like multi-threshold CMOS technology. Power Grid Optimization The power grid ensures that power is delivered uniformly across the chip while minimizing IR drop and electromigration. A poorly designed power grid can lead to significant performance and reliability issues.[10].

- Supervised Learning: ML models have been used to predict IR drop across the power grid based on the layout and power demand of the circuit. By training on past designs, the model can quickly identify regions of the chip that are likely to experience power delivery issues and suggest improvements to the grid design. Achieving PPA Goals with AI : The application of AI in physical design offers significant opportunities for improving PPA metrics:

- Power: AI models can predict high-power areas and suggest optimizations such as clock gating and power gating, leading to reduced dynamic and leakage power.

- Performance: AI can predict timing bottlenecks and suggest layout optimizations to improve critical path delays.

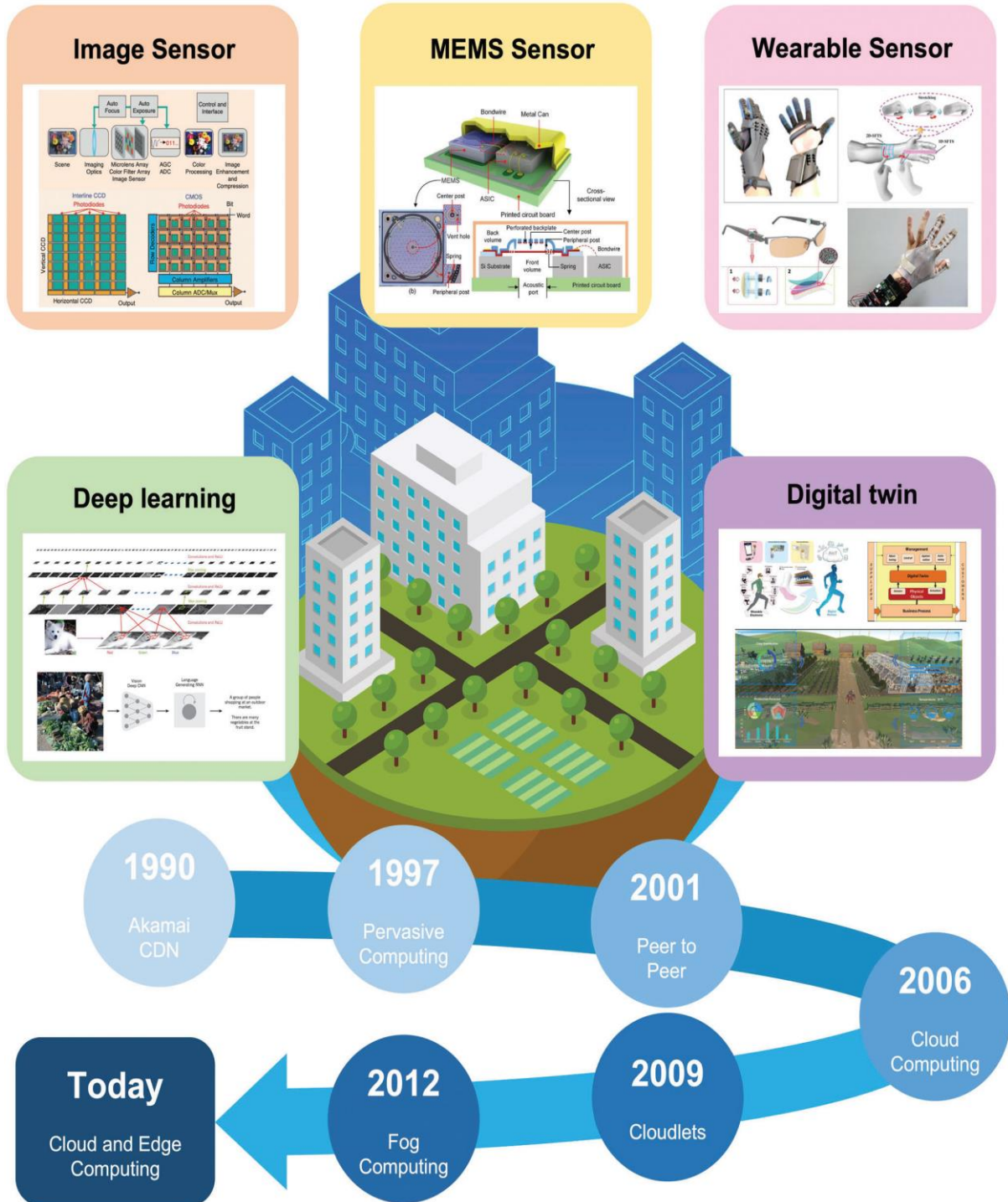
- Area: AI-based clustering techniques can minimize the area consumed by the design , reducing overall chip size.

### 4. Design of AI - Integrated Virtual Sensors:

Virtual sensors can be used in any system where real-time monitoring and control are required, and where the use of physical sensors might be impractical or costly. Leveraging AI techniques can improve the accuracy and reliability of virtual sensors , designing them using Kalman filtering and other techniques . AI is a newer option that, in some cases, can improve the design of virtual sensors as an addition or alternative to other methods. With MATLAB and Simulink. Design virtual sensors using AI includes data Collection , AI modeling, system simulation, and deployment.

Virtual sensors are software components that mimic the behavior of a physical sensor by using other measurements or data available to estimate the quantity of interest. They are commonly used in many industries and applications to monitor and optimize processes, or estimate environmental conditions.

This section talks about using AI to design virtual sensors and shows how: You can quickly train and compare different AI models in MATLAB to implement a virtual sensor or import AI models from other deep learning frameworks.



**Fig 1 : Data Collection from sensors changing era from 1990 for prediction using supervised Deep Learning**

### 5. Data Preparation:

The design process can be limited or constrained by the quality or availability of data. MATLAB can help you improve the data quality by using signal processing techniques to remove noise and extracting meaningful standard and domain-specific features from the data.

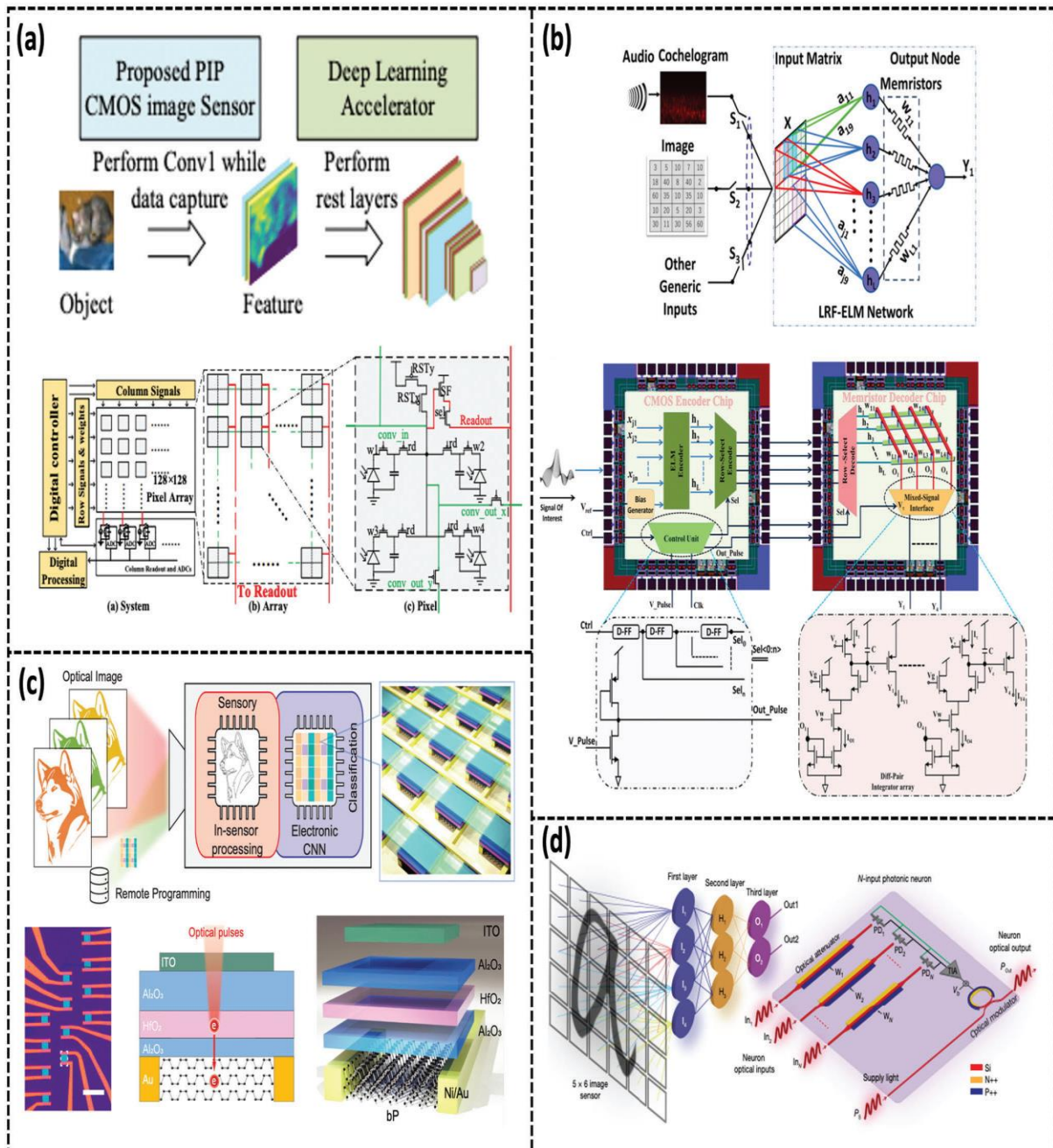


Fig (2) : Proposed System for Data Collection based on IoT.

## 6. AI based Modeling for sensors:

To develop a virtual sensor, you can train an AI model by using a machine learning algorithm (e.g., SVM, linear regression, and neural network) with a few lines of MATLAB code.

Create an LSTM (long short-term memory) model for sequence-to-one regression. LSTMs are particularly effective in working with sequential data that varies in length. For an example on how to predict the remaining useful life (RUL) of designed system.

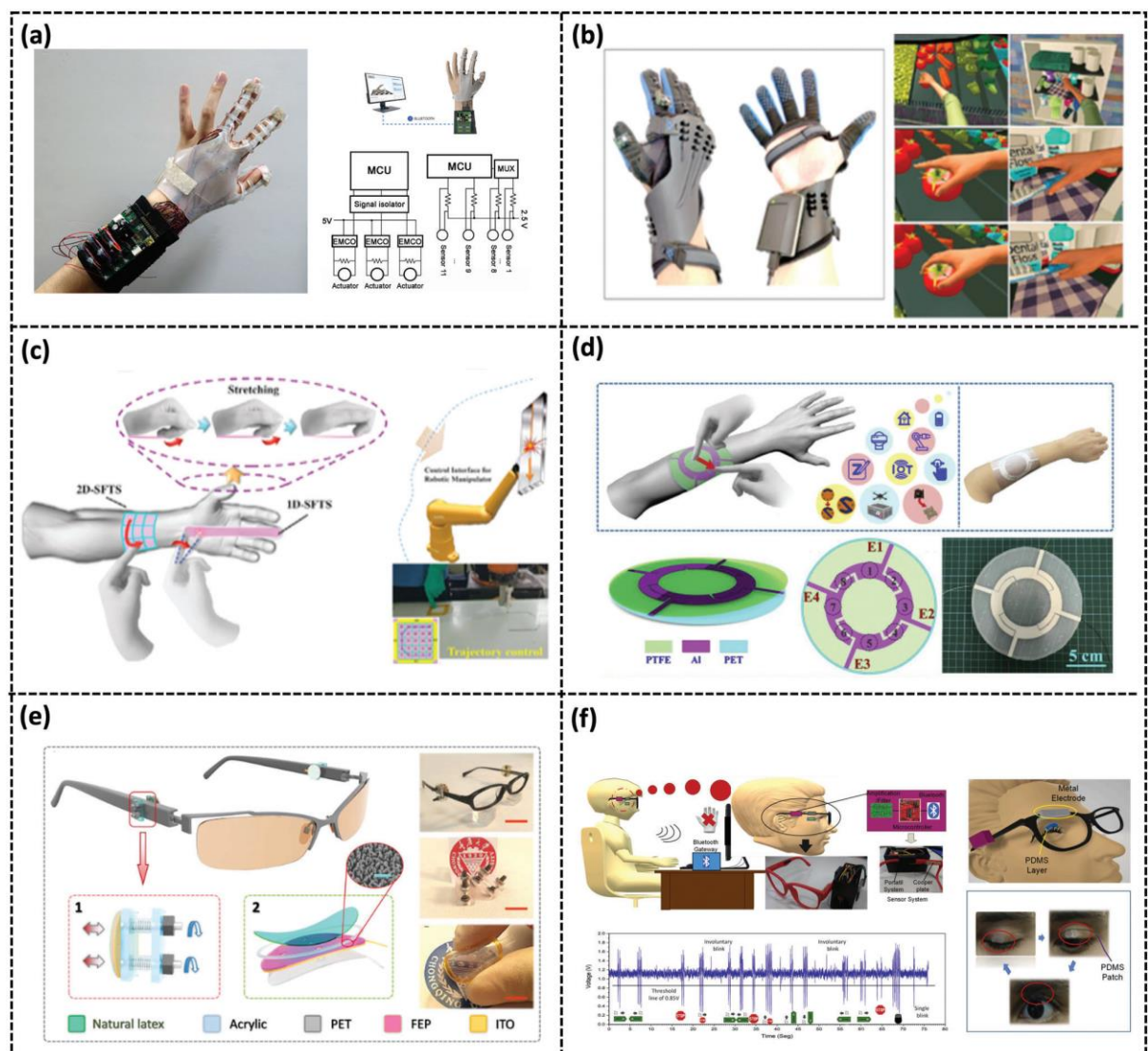


Fig (3) : AI based modeling of sensors for predicting outcome of system

## **7. Conclusion:**

Our review systematically introduces the recent progress of the rapid development of sensors with AI in the field of image sensors, acoustic sensors, Virtual sensors and their respective AI algorithms is implemented. We focused on data optimization on edge computing by integrating of sensing element, computation element together, which will provide an emerging platform with short response time, low power consumption and high transmission efficiency for IoT compared with conventional cloud computing. Various AI algorithms have risen great growth in the applications of object recognition, object detection.

We reviewed in detail their design considerations, working mechanisms, application scenarios, and potentials for security, automation, healthcare, environment monitoring, human computer interaction in smart home and smart farming.

MATLAB and Simulink provide implementation and analysis of physics tools to improve data quality, access to supervised learning algorithms, integration with a system-wide simulation environment, and deployment to the real-world system. The best AI technique for designing an accurate virtual sensor, but for designing and deploying a virtual sensor that will run efficiently on the intended system.

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