

Diagram illustrating the relationship between a black-box model and an interpretable model.

On the left, a black-box model takes an **Input** and produces an **Output** through a function $\mathbf{h}(\cdot; \theta)$.

On the right, an interpretable model takes the same **Input** and produces the same **Output** through a sequence of layers: $h^1(\cdot; \theta^1) \rightarrow h^2(\cdot; \theta^2) \rightarrow \dots \rightarrow \text{Output}$.

A vertical dashed line separates the two models.

Annotations for the interpretable model:

- End-to-end Training**: A box above the sequence with dotted arrows pointing to the input and output of the entire sequence.
- Interpretable layers**: A box below the sequence with dashed arrows pointing to the individual layers h^1 and h^2 .

PSHoloNet Backbone Architecture

The architecture processes QIS data through multiple phases (Phase 1, Phase 2, ..., Phase T). Each phase consists of three sequential blocks: v update, ϕ update, and α update. The α update blocks are task-oriented and receive input from trainable parameters ρ_1^t, ρ_2^t . The final output is compared with the Ground Truth to calculate the Loss. The legend indicates: Closed-form expression (light brown), Trainable Parameters (dark brown), Task-oriented (hatched), Back-propagation (dashed line), and Input to block (solid line).

Example Tasks

Photon-starved 3D particle detection

- α update: Closed-form expression
- 3D location: Task-oriented
- Loss function: MSE loss

Photon-starved phase imaging

- α update: Closed-form expression
- Phase map: Task-oriented
- Loss function: MSE loss, NPCC loss