Indoor Lighting Estimation using an Event Camera

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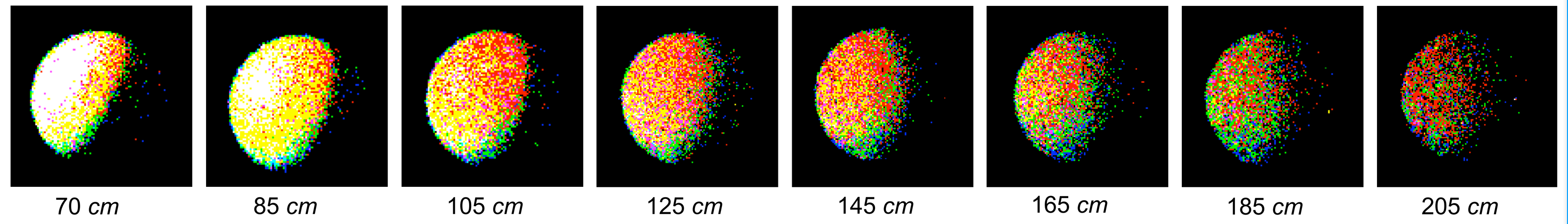
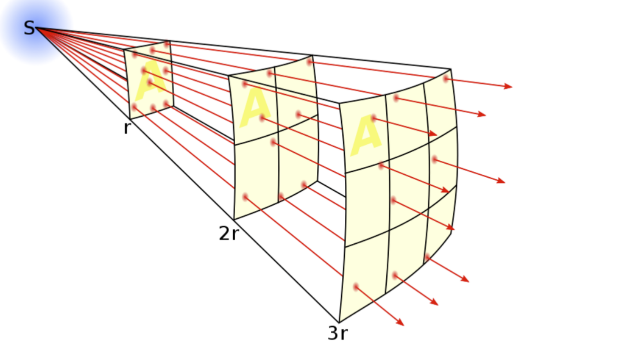
PROBLEM DESCRIPTION

Take an image as input, predict a set of parameters(lighting distance, direction, lighting intensity,...) which represents the illumination conditions.

OBSERVATION

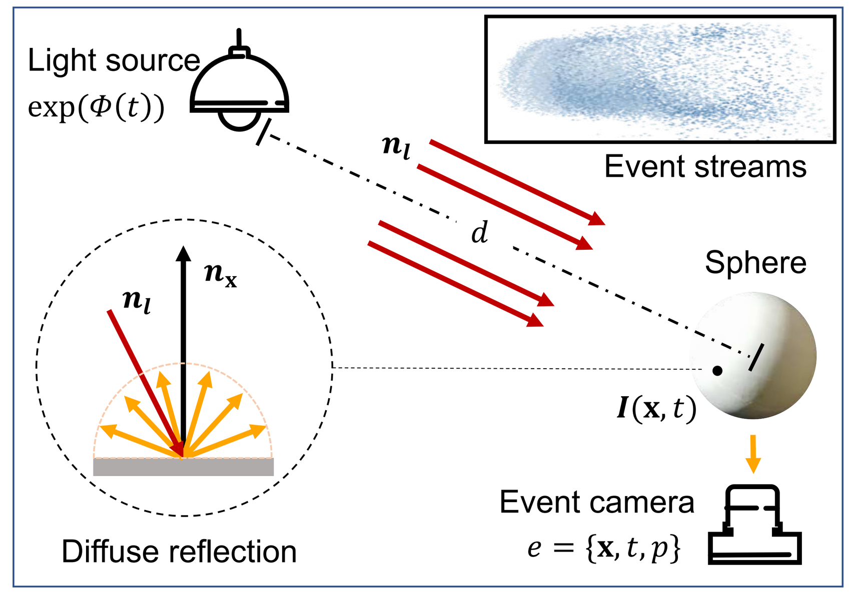


- RGB image as the input suffers from the problem of intensity-distance ambiguity (Inverse-square law)
- Event streams are sensitive to lighting distance



NOVEL SETUP

- An event camera to capture the intensity changes
- on a purely diffuse sphere
- placed in a dark room
- for the split second of turning light on



BASIC IDEA

- Radiant intensity from event streams:

$$I_e(\boldsymbol{x}, t) = I_0 exp(C\int_{t_0}^{t} e(\boldsymbol{x}, t)dt)$$

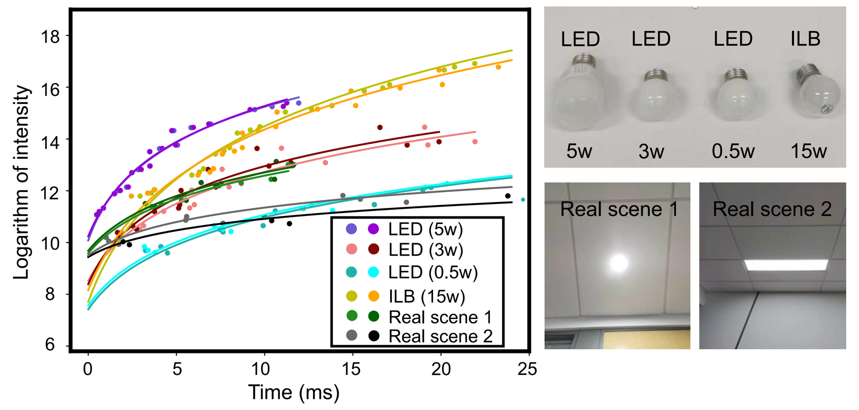
- Analytic formulation of radiant intensity:

$$I(\boldsymbol{x}, t) = \rho L(t)\max(<\boldsymbol{n}_l, \boldsymbol{n}_x>, 0),$$

$$L(t) = \frac{\exp(\Phi(t))}{4\pi d^2}$$

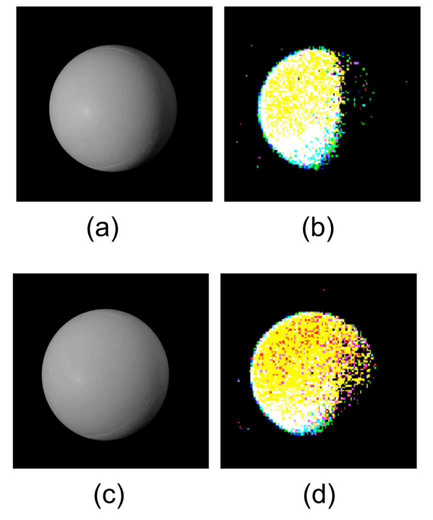
- Assumption of $\Phi(t)$:

$$\Phi(t) = alg(t + c) + b$$



ALLEVIATING THE AMBIGUITY

- Intensity-distance ambiguity exists only if the following equation holds:
$$\exp(\Phi_1(t)) = \exp(\Phi_2(t)), \forall t \in [t_0, t_n]$$
- For RGB input:
$$\exp(\Phi_1(t_n)) = \exp(\Phi_2(t_n))$$



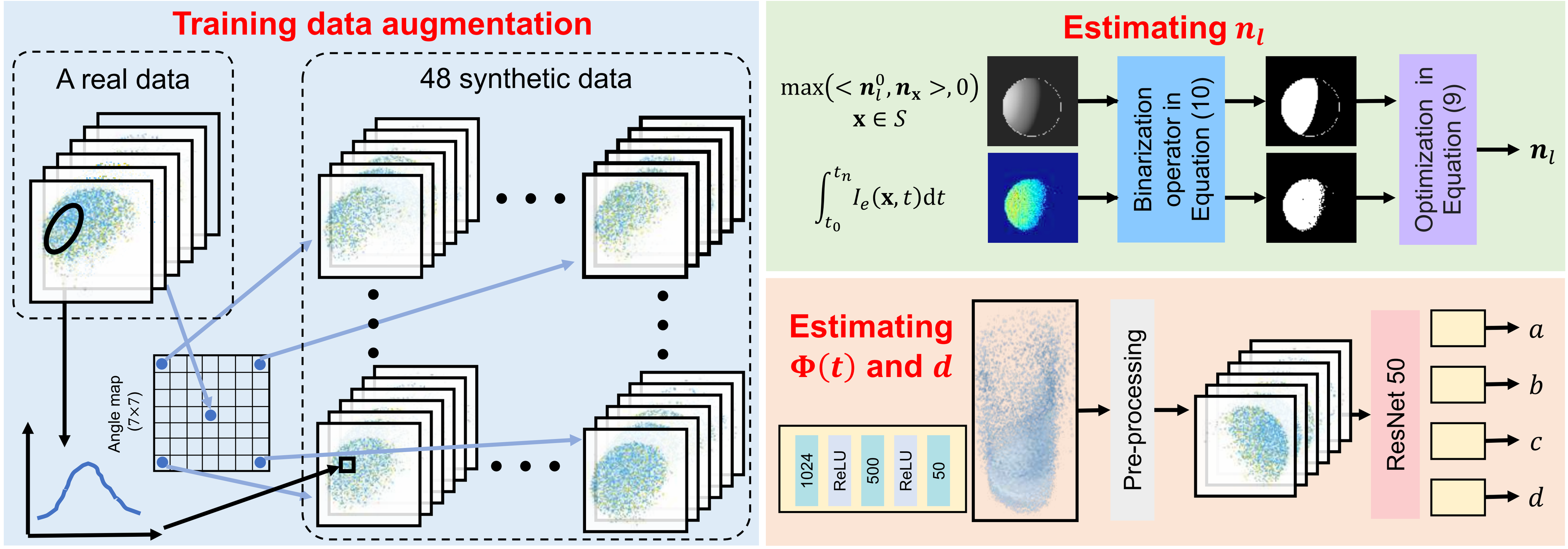
TWO SOLUTIONS

- **Optimization based method**

$$\min_{d, \boldsymbol{n}_l, a, b, c} \int_S \int_{t_0}^{t_n} ||I_e(\boldsymbol{x}, t) - I(\boldsymbol{x}, t)|| dt d\boldsymbol{x}$$

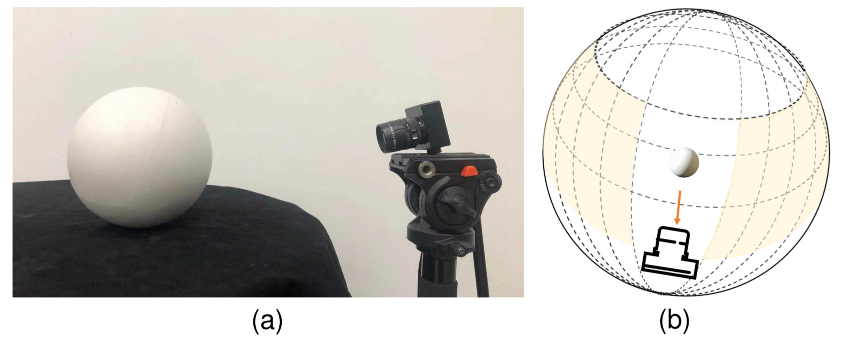
Well-posed: More than 50 constrains and only 6 unknows

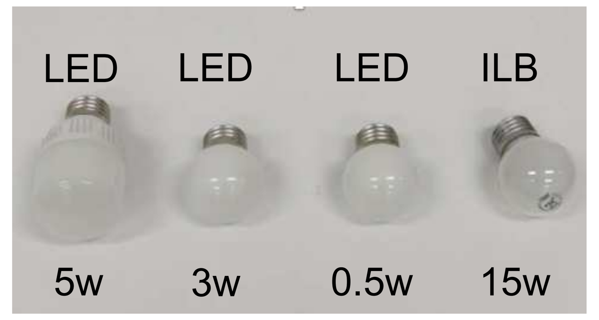
- **Learning based method**

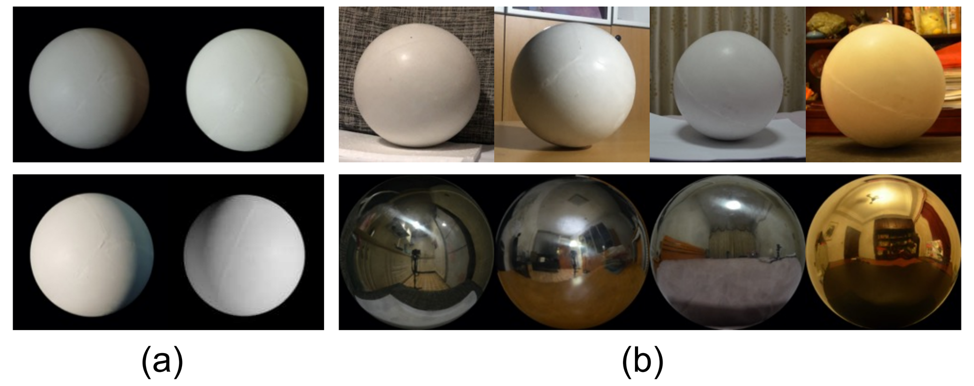


DATA COLLECTION

- Training: synthetic data
- Testing:
  - (a) Controlled data: 240
  - (b) Wild data: 363

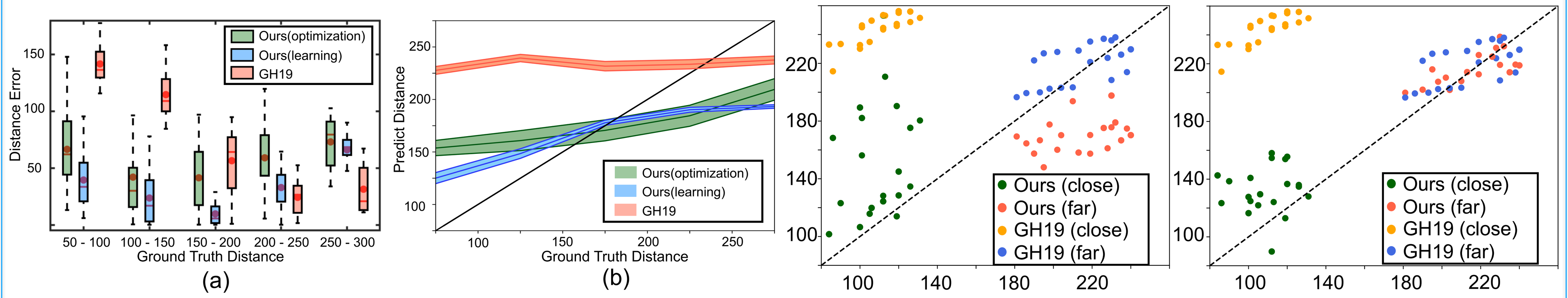




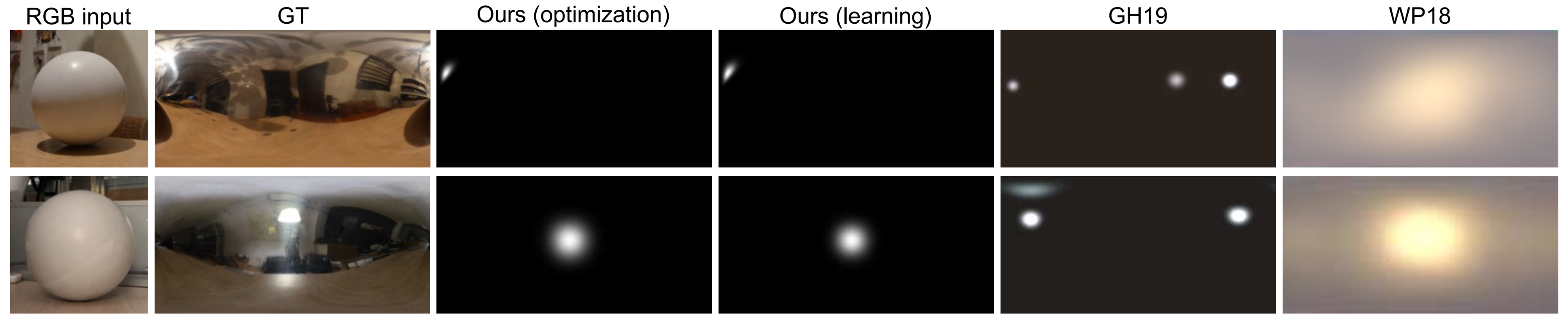


EXPERIMENTS

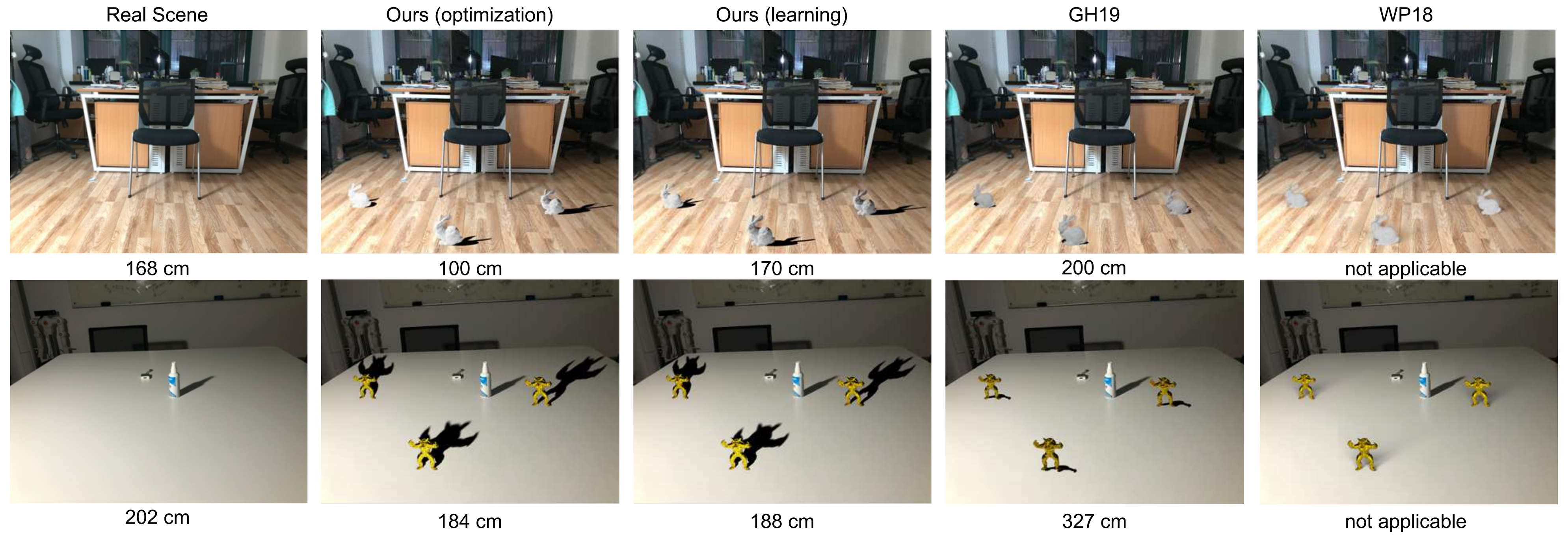
- Overall performance
- Validation for ambiguity alleviation



- Visual comparison of environment maps for data in wild datasets



- Visual comparison of object insertion results for data in wild datasets



CONTRIBUTIONS

- Introduce a novel setup which can be alleviated the intensity-distance ambiguity for the problem of indoor lighting estimation.
- Show that estimating lighting distance becomes a well-posed problem with our setup, and propose two methods.
- Show the proposed methods not only achieve superior performance but also significantly alleviate the intensity-distance ambiguity for the problem of indoor lighting estimation.