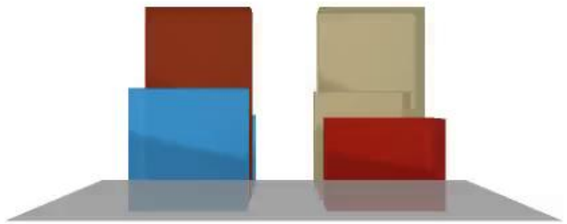
UCLouvain

Radio Propagation Modeling in an Urban Scenario using Generative Ray Path Sampling

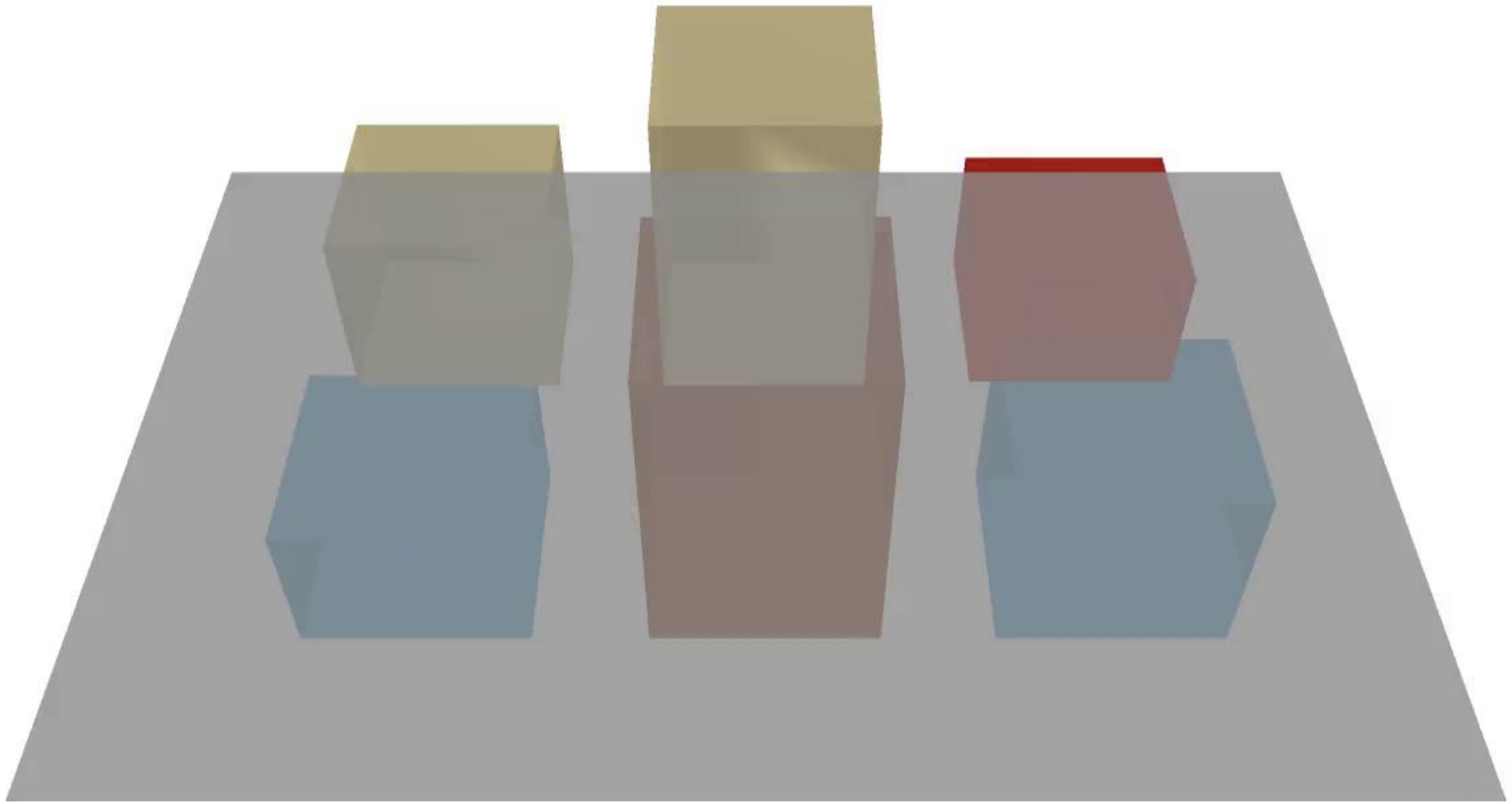
Jérome Eertmans - January 27-30, Dublin

Authors: Jérome Eertmans, Nicola Di Cicco, Claude Oestges, Laurent Jacques, Enrico Maria Vitucci, Vittorio Degli-Esposti

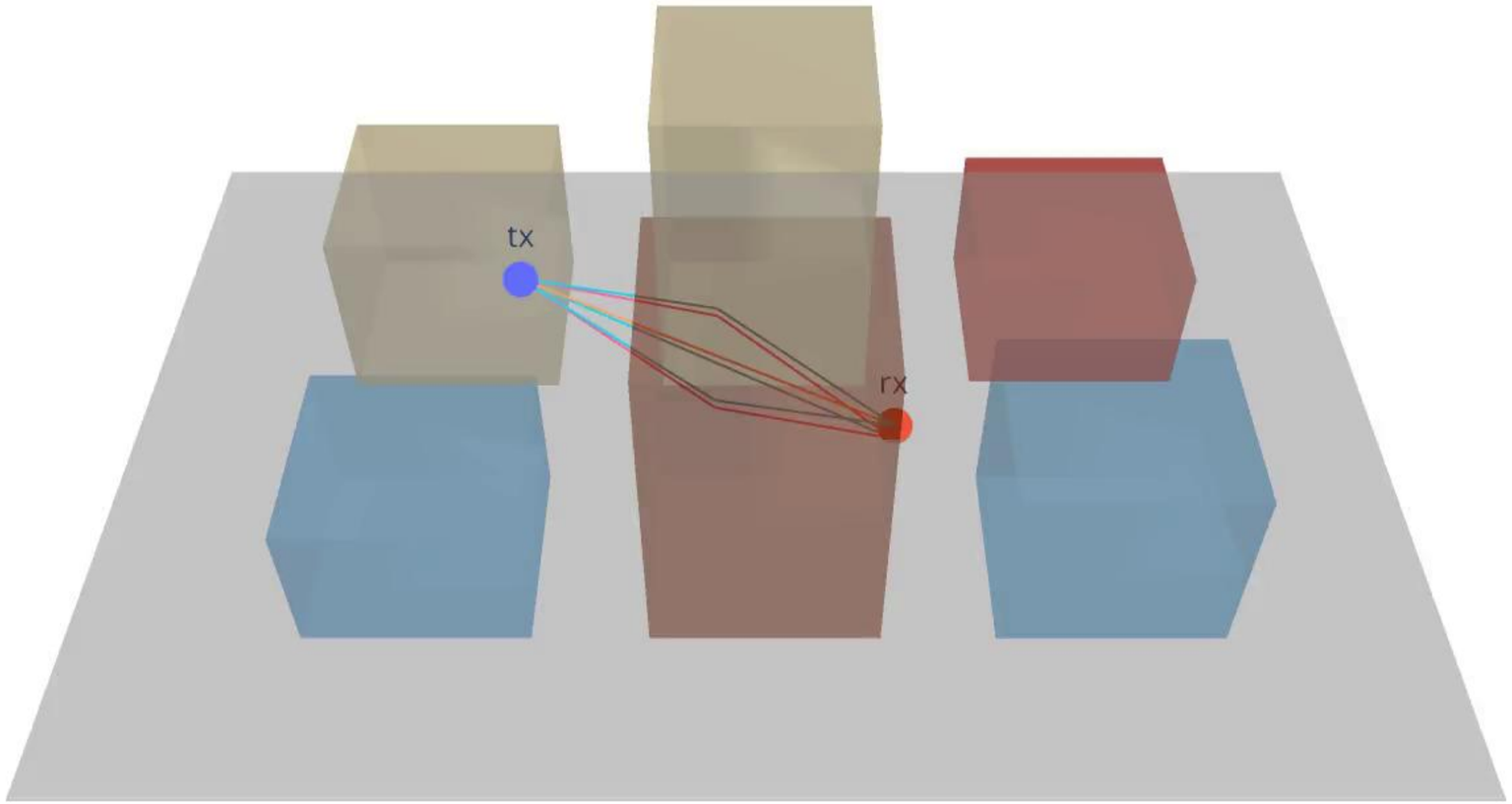
Context



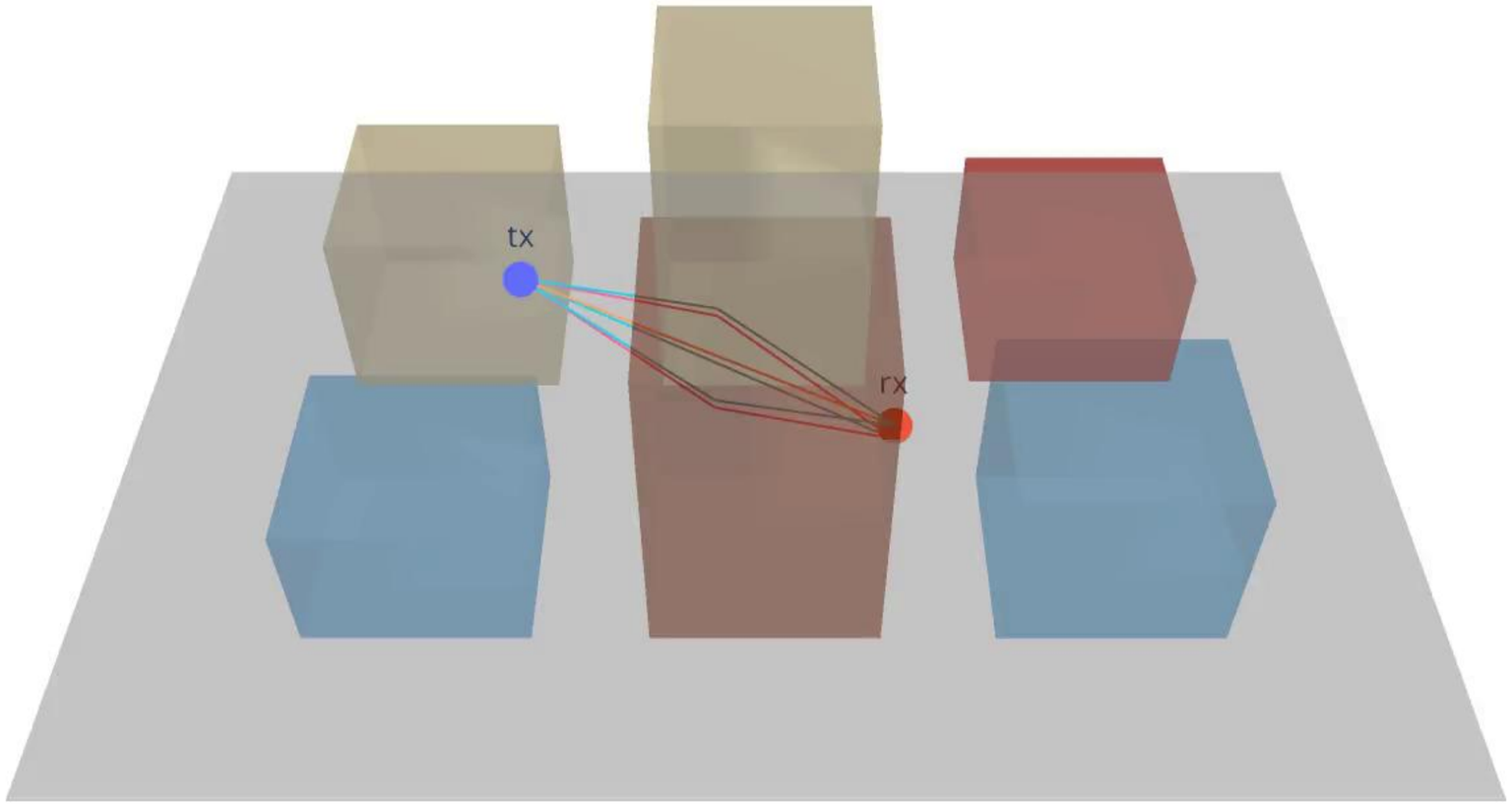
Context



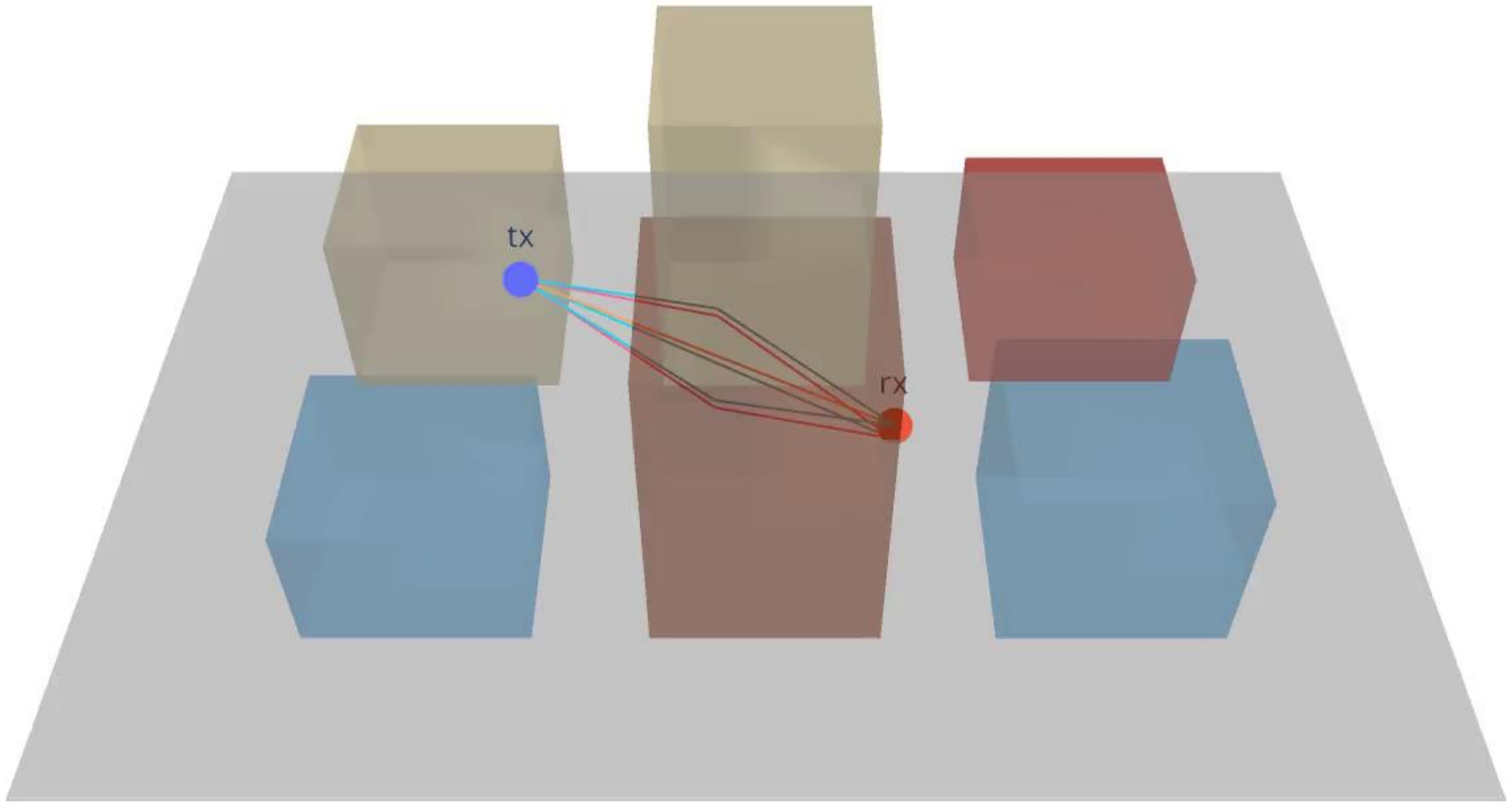
Context



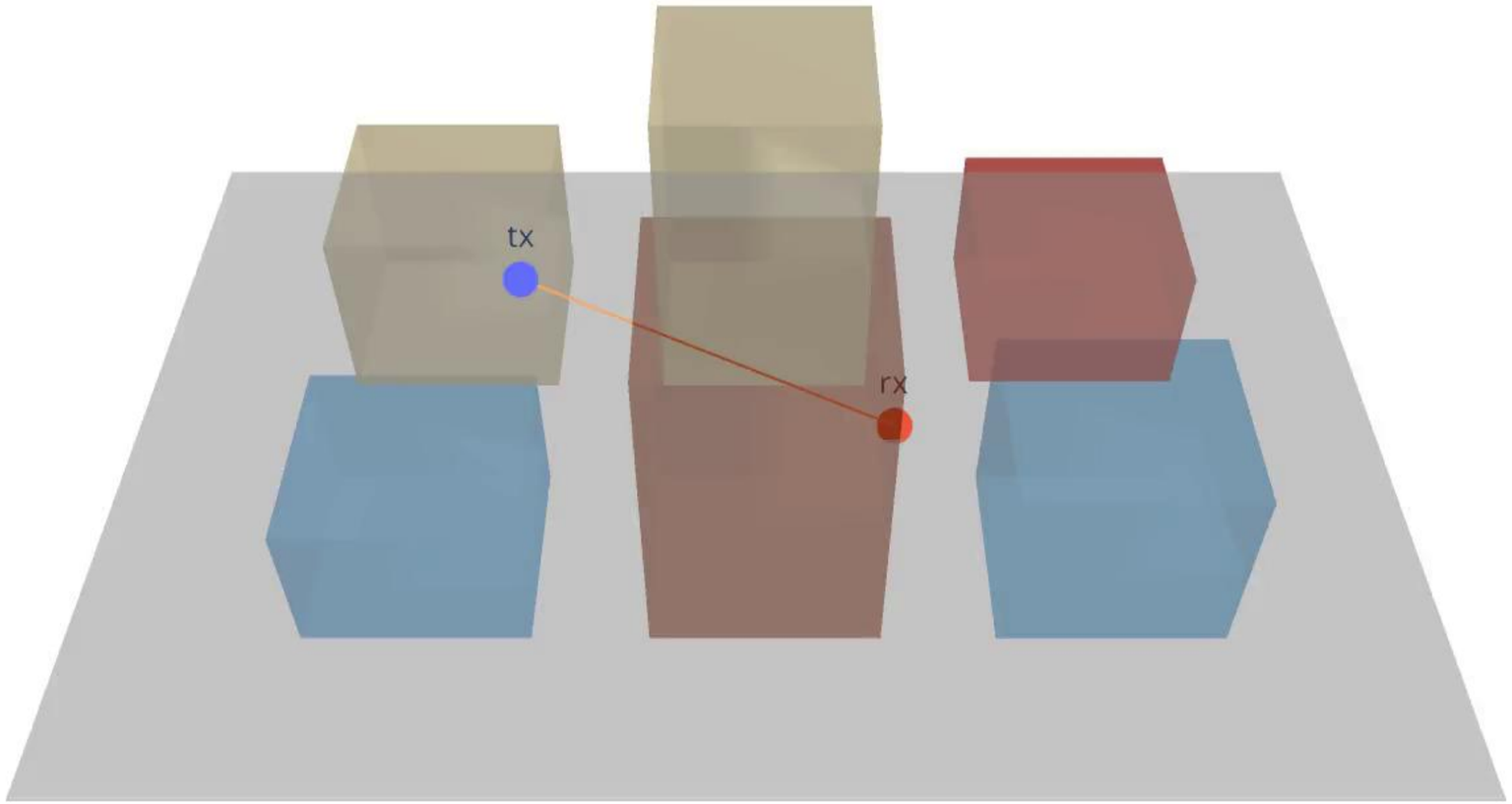
Context



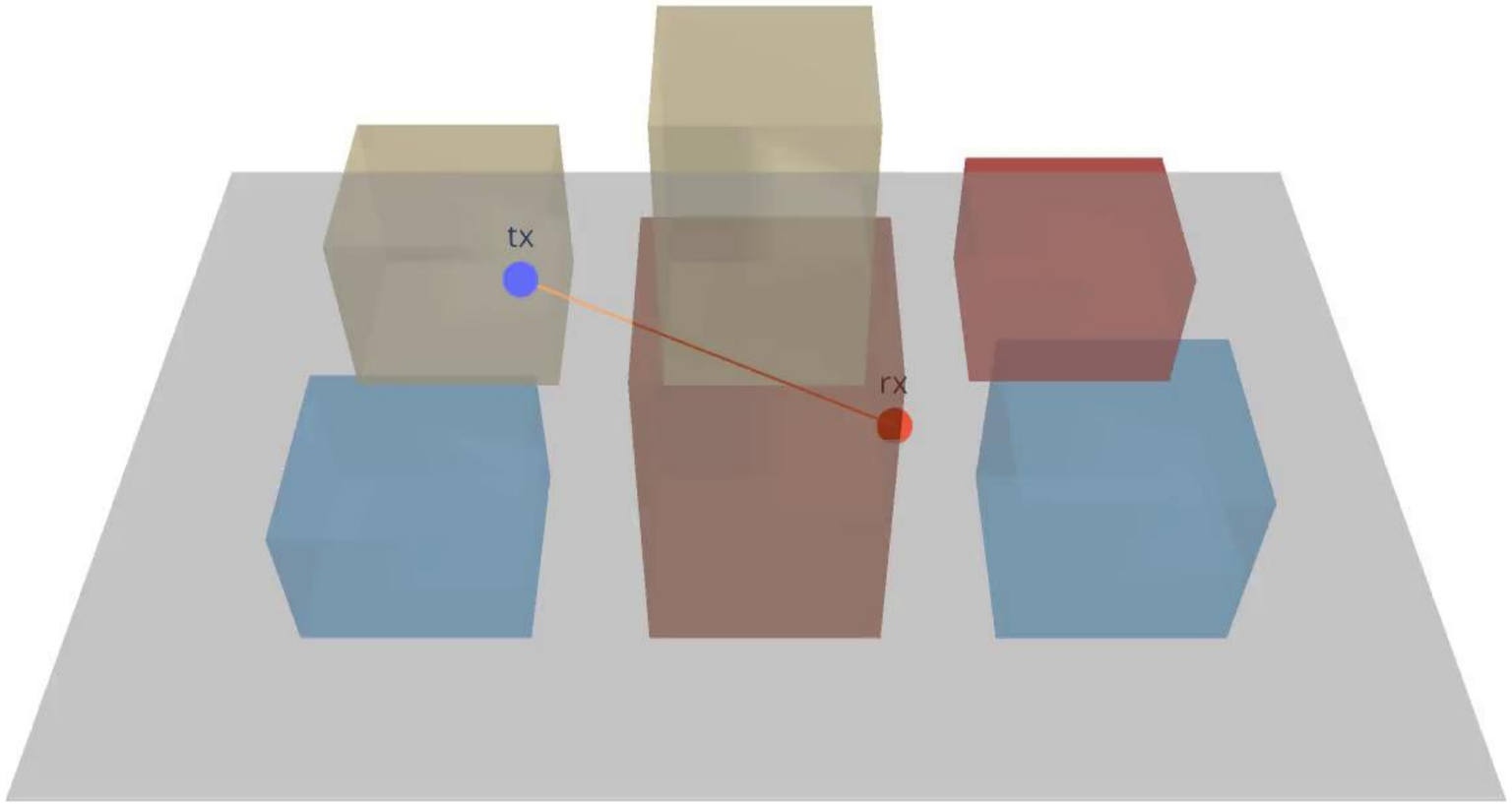
Context



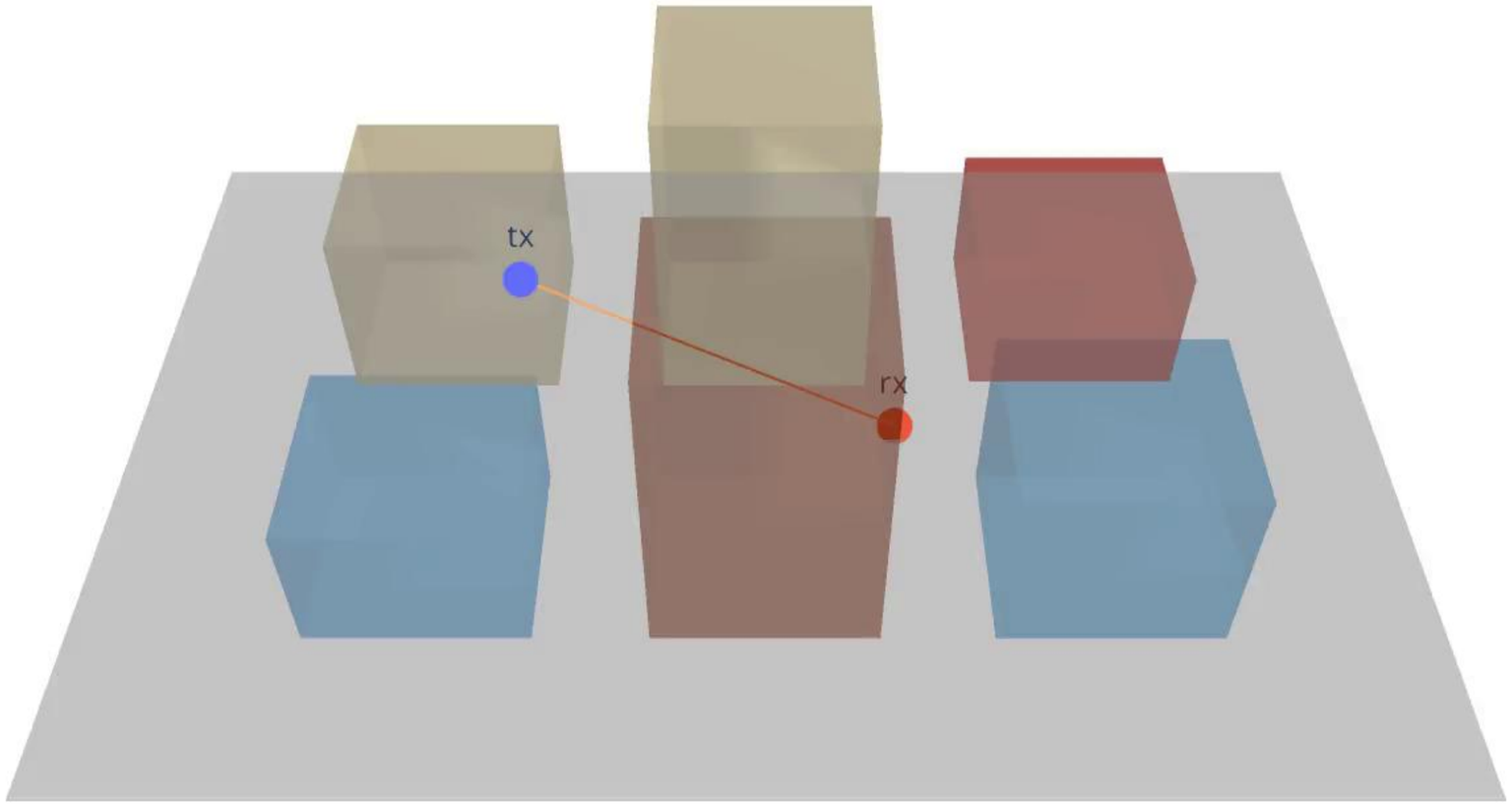
Context



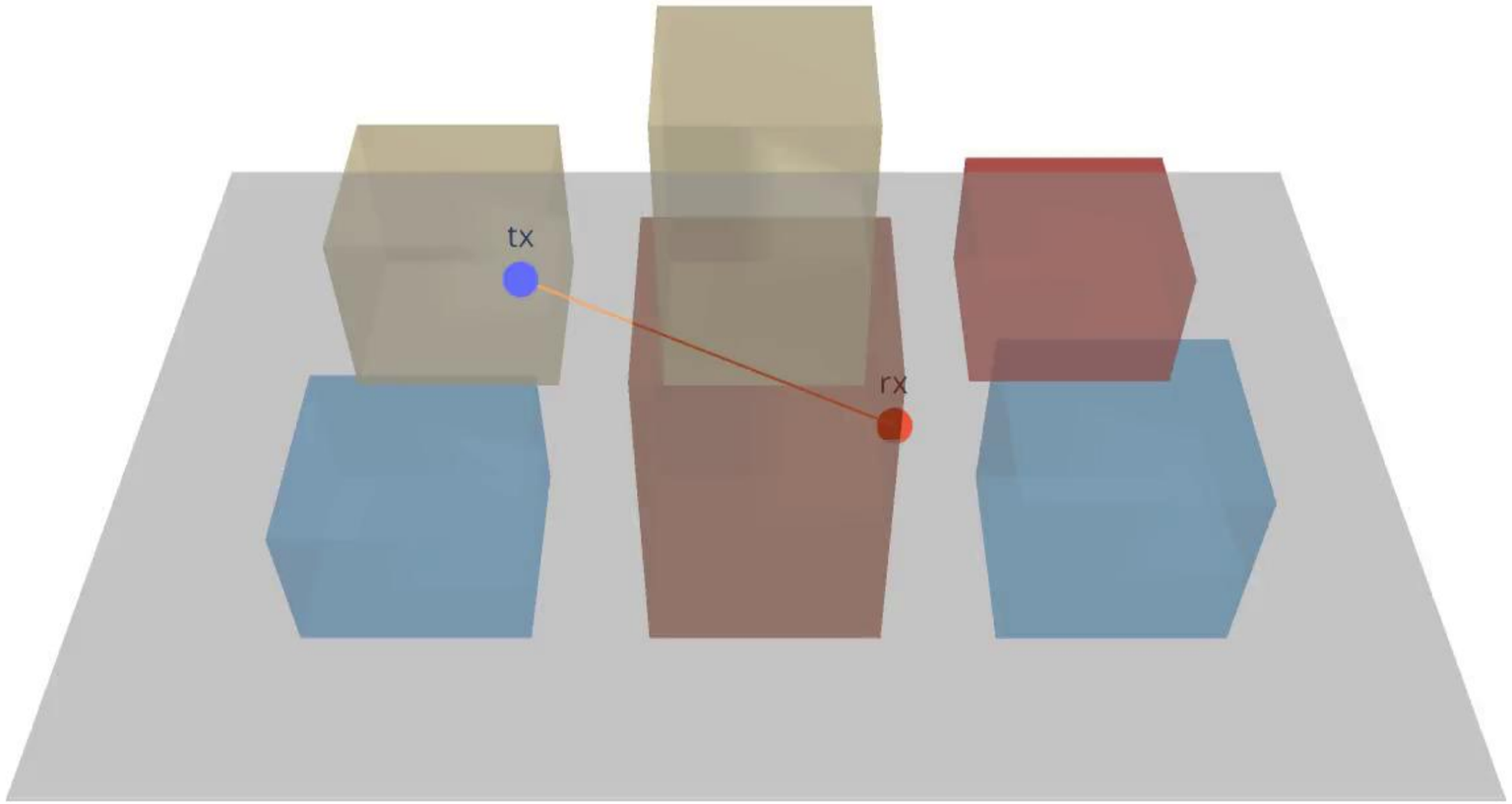
Context



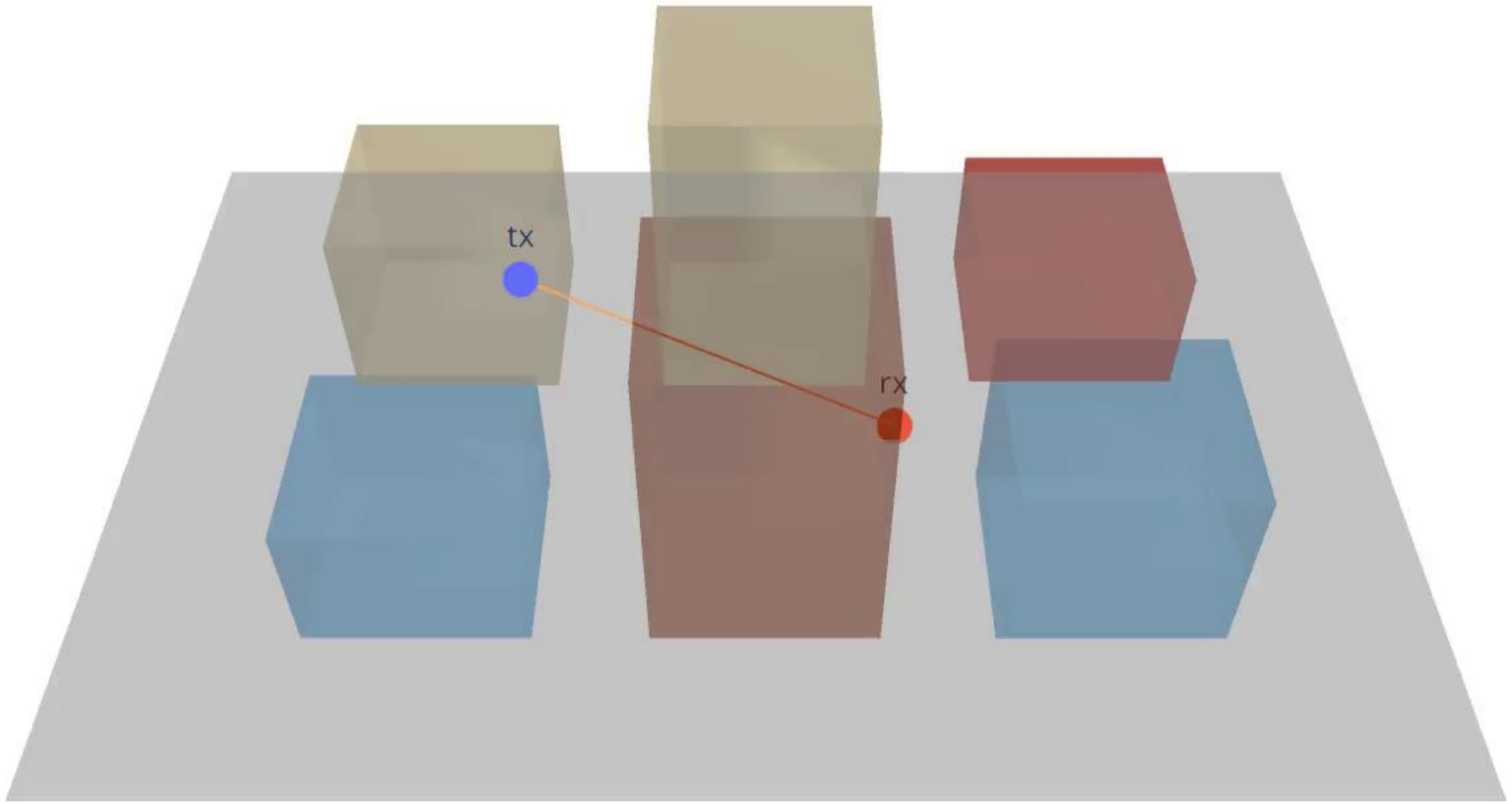
Context



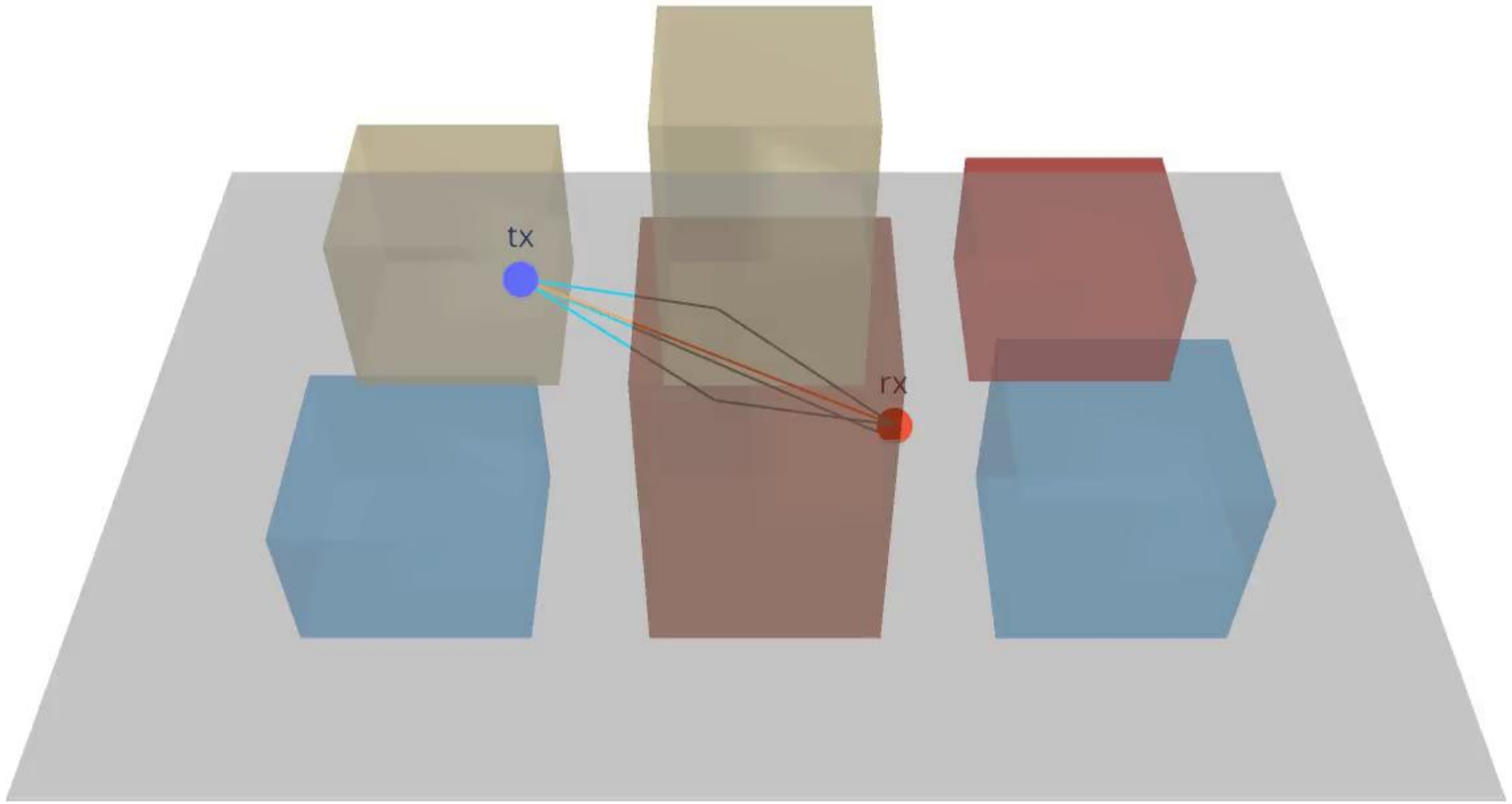
Context



Context

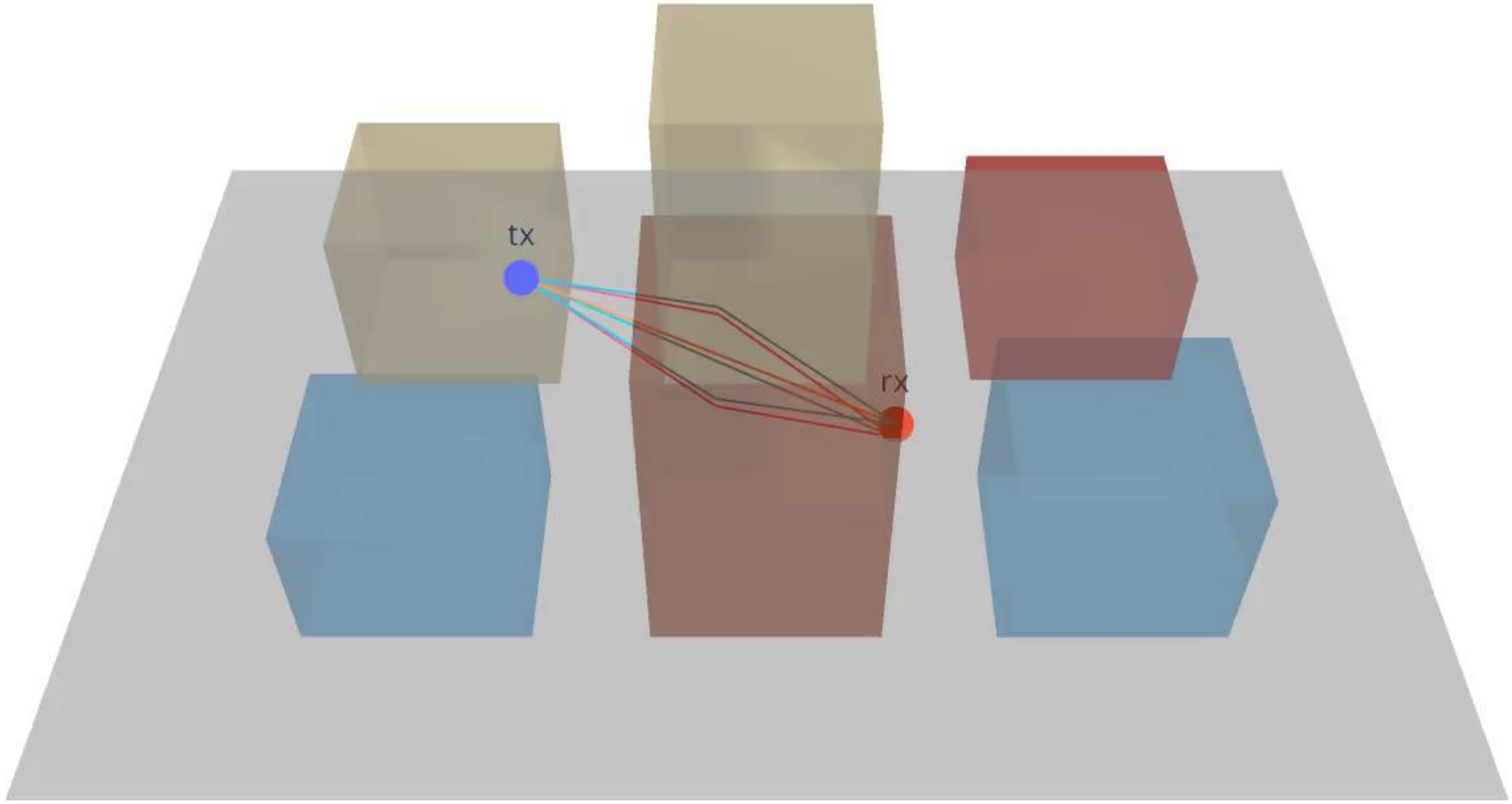


Context



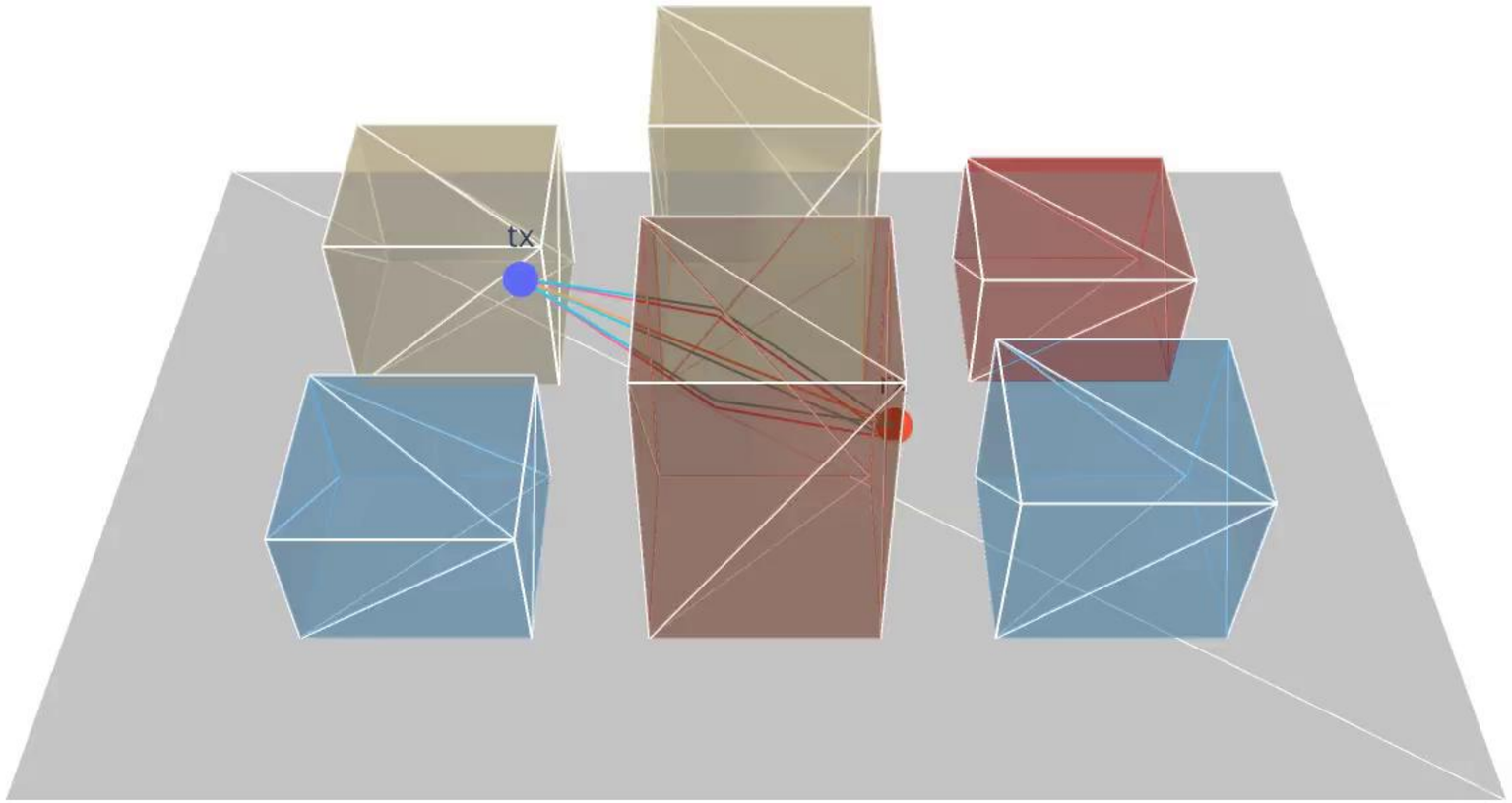
Context

1332



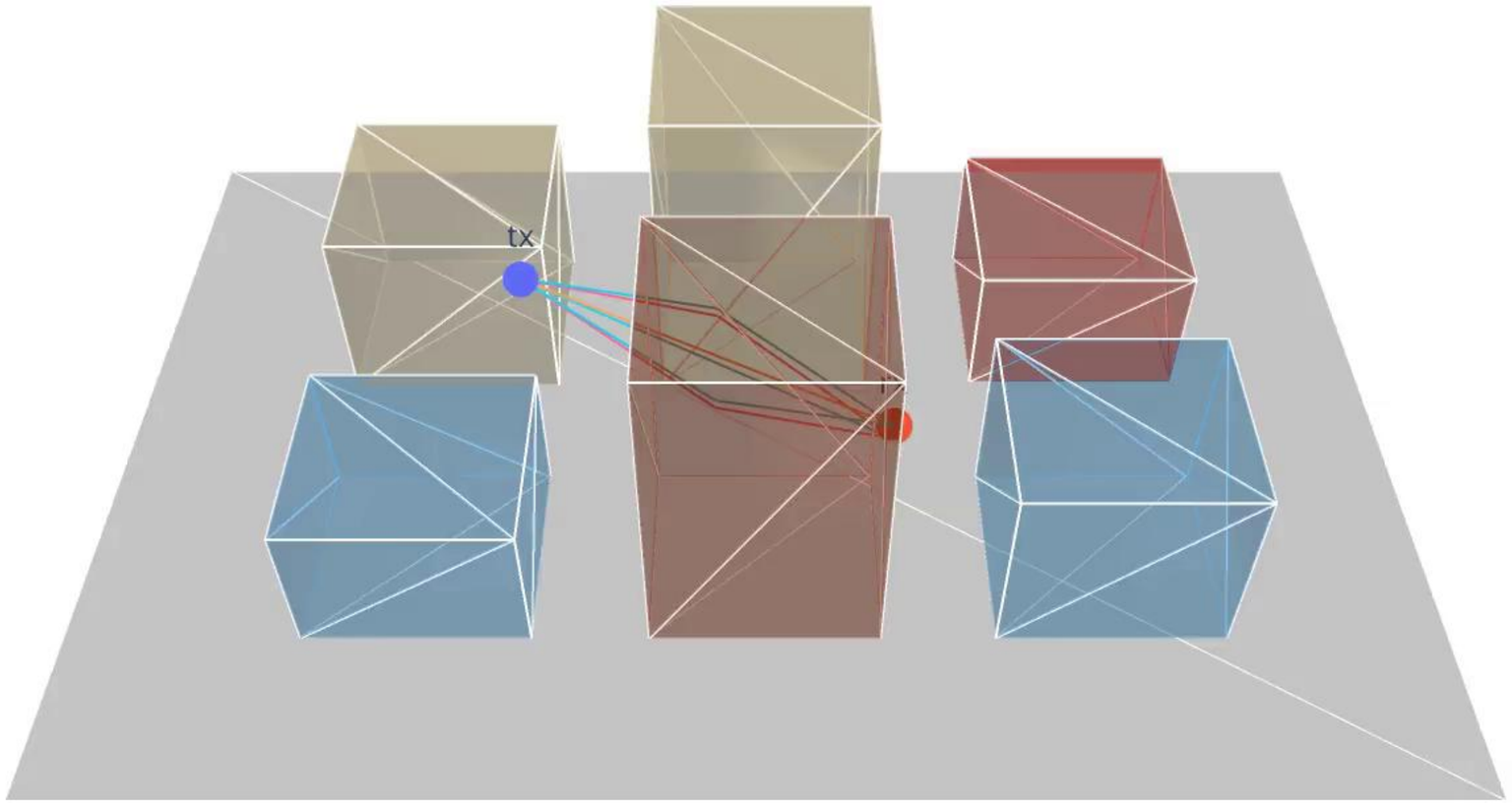
Context

1332

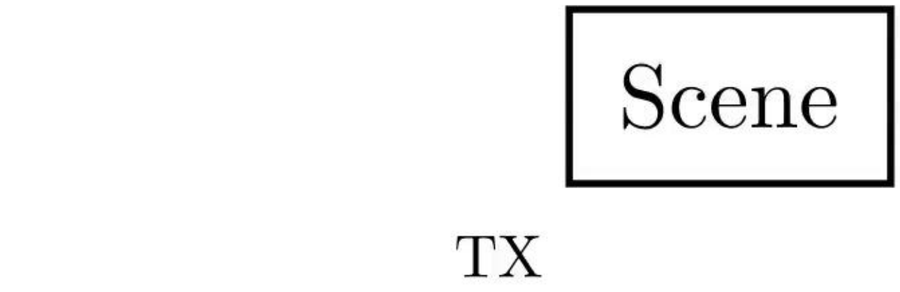


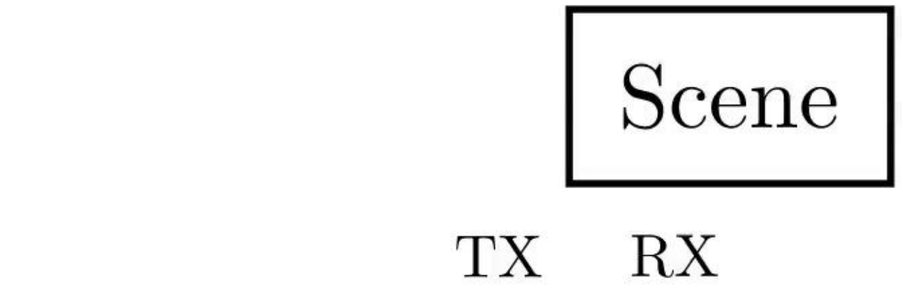
Context

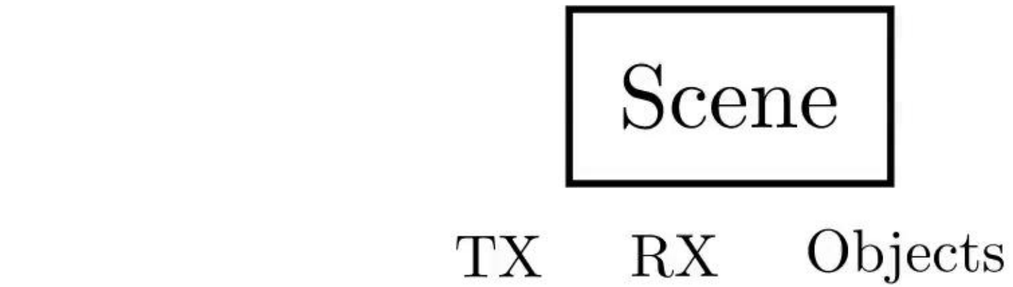
5402

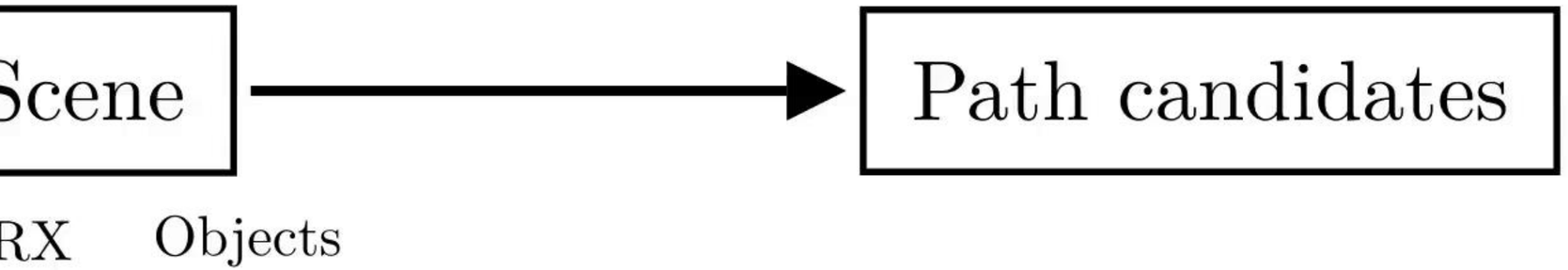


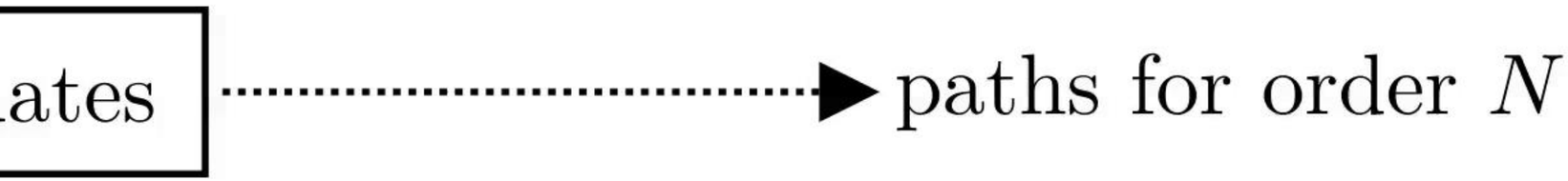

Scene


Scene
TX

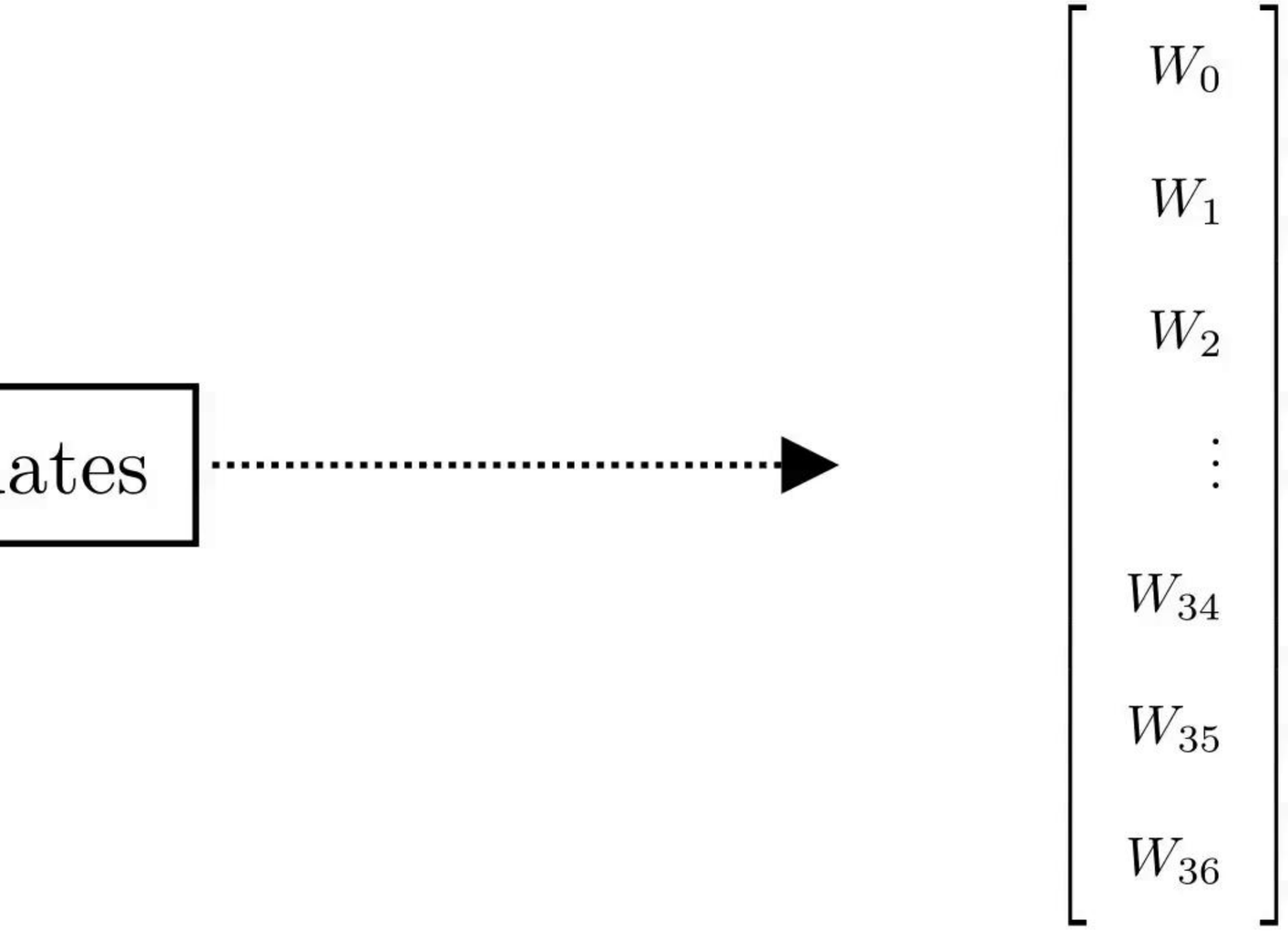

Scene
TX
RX


Scene
TX
RX
Objects


Scene
Path candidates
RX
Objects


ates
paths for order N

ates



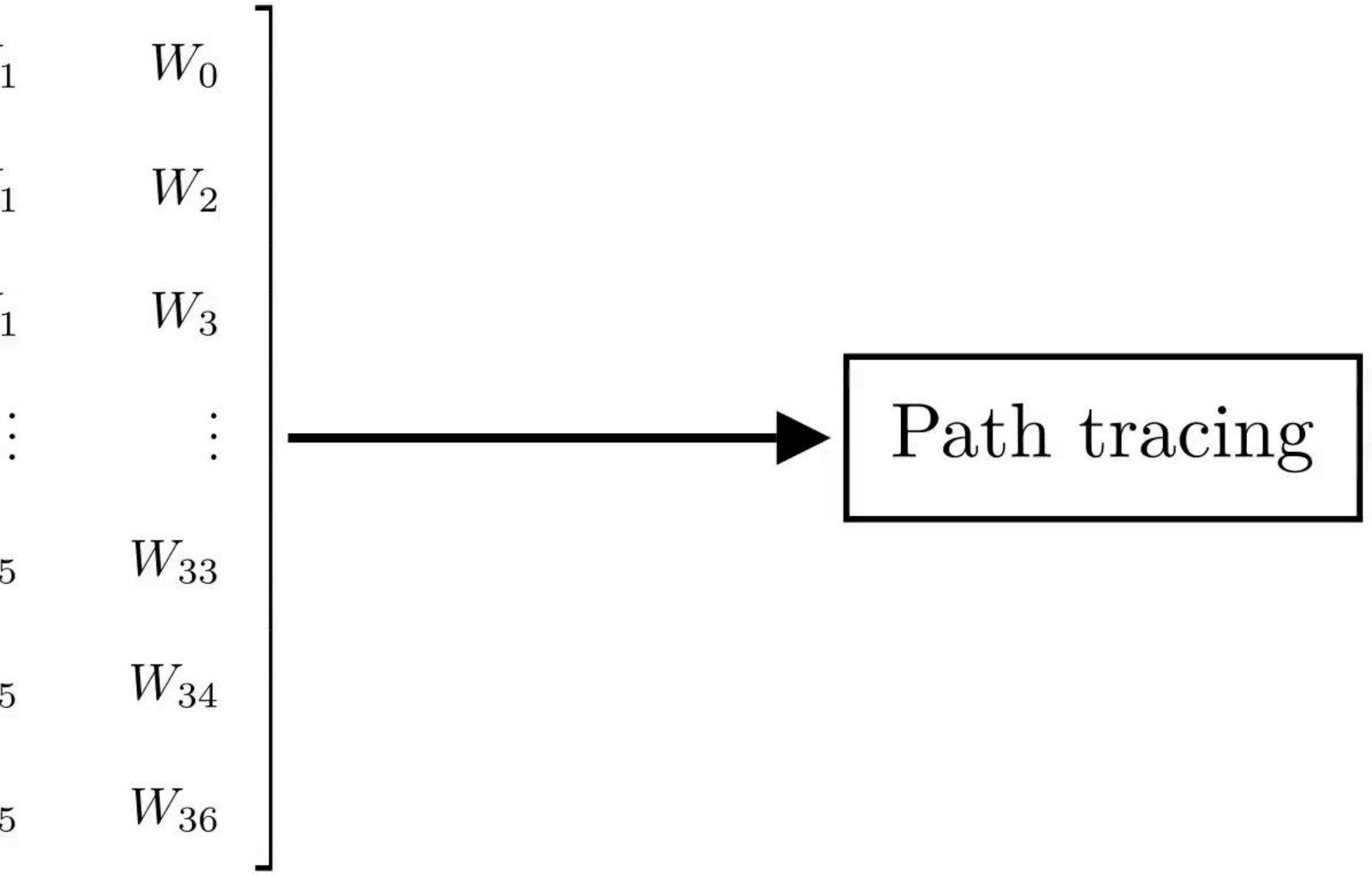
$$\begin{bmatrix} W_0 \\ W_1 \\ W_2 \\ \vdots \\ W_{34} \\ W_{35} \\ W_{36} \end{bmatrix}$$

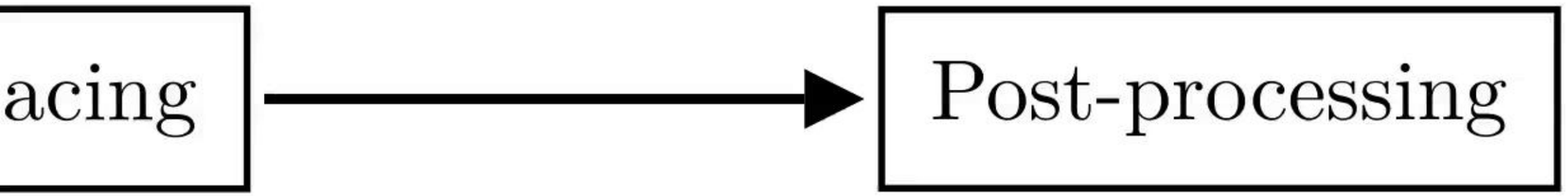
ates

$$\begin{bmatrix} W_0 & W_1 \\ W_0 & W_2 \\ W_0 & W_3 \\ \vdots & \vdots \\ W_{36} & W_{33} \\ W_{36} & W_{34} \\ W_{36} & W_{35} \end{bmatrix}$$

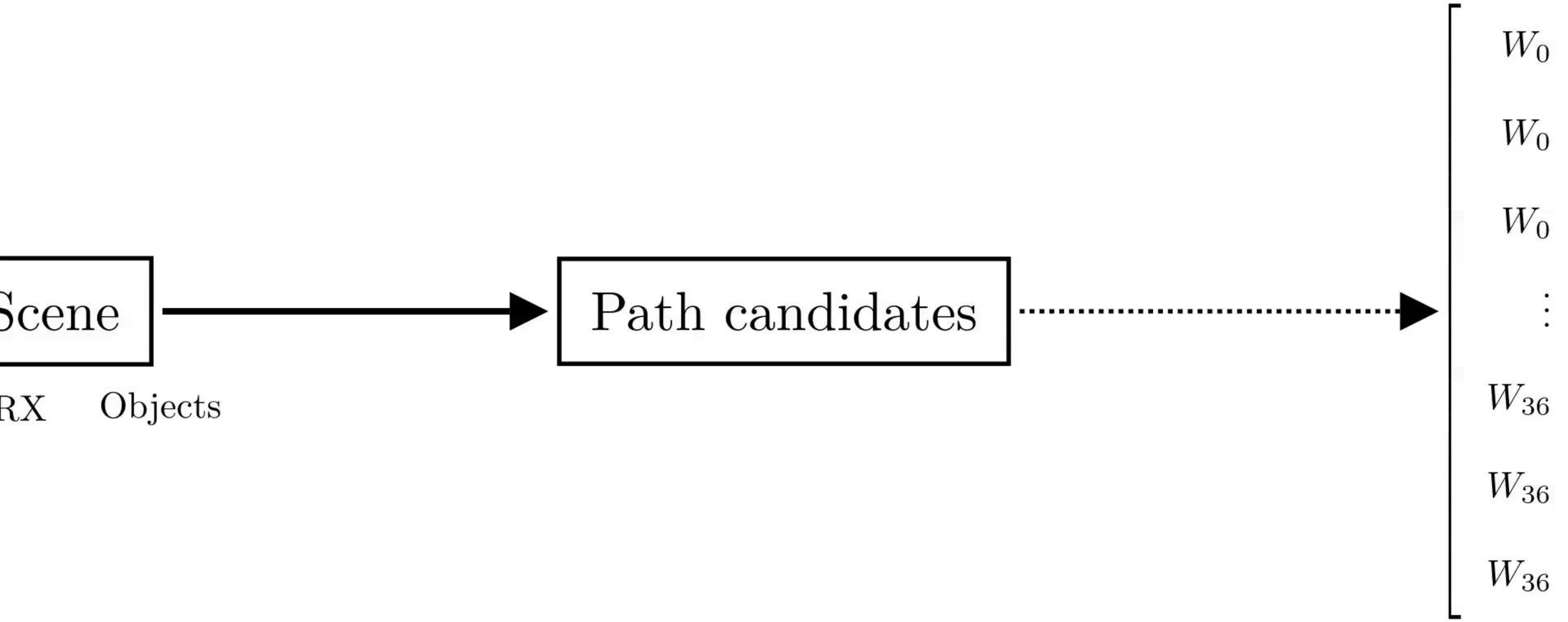
ates

$$\begin{bmatrix} W_0 & W_1 & W_0 \\ W_0 & W_1 & W_2 \\ W_0 & W_1 & W_3 \\ \vdots & \vdots & \vdots \\ W_{36} & W_{35} & W_{33} \\ W_{36} & W_{35} & W_{34} \\ W_{36} & W_{35} & W_{36} \end{bmatrix}$$

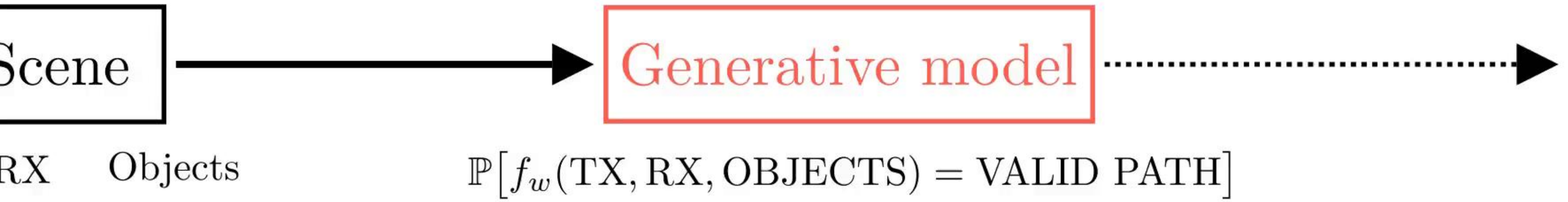

W_0
W_2
W_3
W_{33}
W_{34}
W_{36}
Path tracing


acing
Post-processing

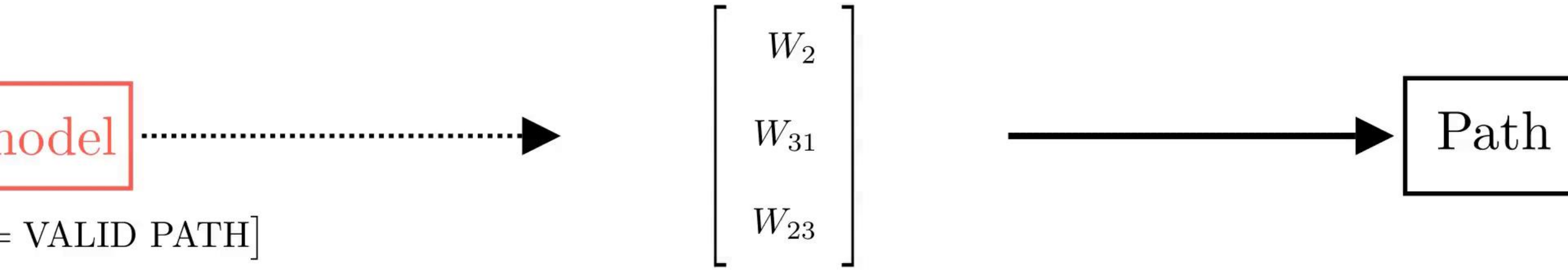

rocessing
EM fields

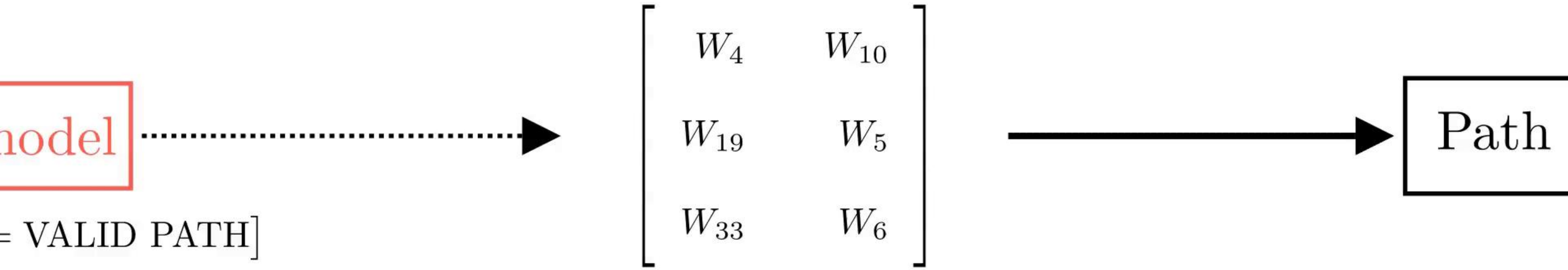

Scene
RX
Objects
Path candidates
W_0
W_0
W_0
W_{36}
W_{36}
W_{36}

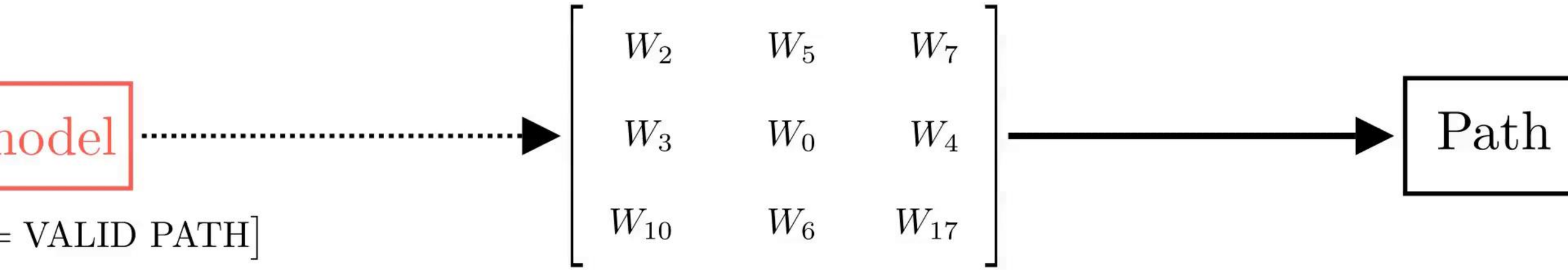
RX Objects


Scene
Generative model
RX
Objects
$\mathbb{P}\big[f_w(\mathrm{TX}, \mathrm{RX}, \mathrm{OBJECTS}) = \mathrm{VALID\ PATH}\big]$

= VALID PATH]


model
= VALID PATH]
W_2
W_{31}
W_{23}
Path


model
= VALID PATH]
W_4 W_{10}
W_{19} W_5
W_{33} W_6
Path


model
= VALID PATH]
W_2 W_5 W_7
W_3 W_0 W_4
W_{10} W_6 W_{17}
Path

Model details:

1. Does not learn a specific scene
2. Arbitrary sized input scene
3. Reinforcement-based learning

What we train on:

What we train on:

Accuracy: % of valid rays over the number of generated rays

What we train on:

Accuracy: % of valid rays over the number of generated rays

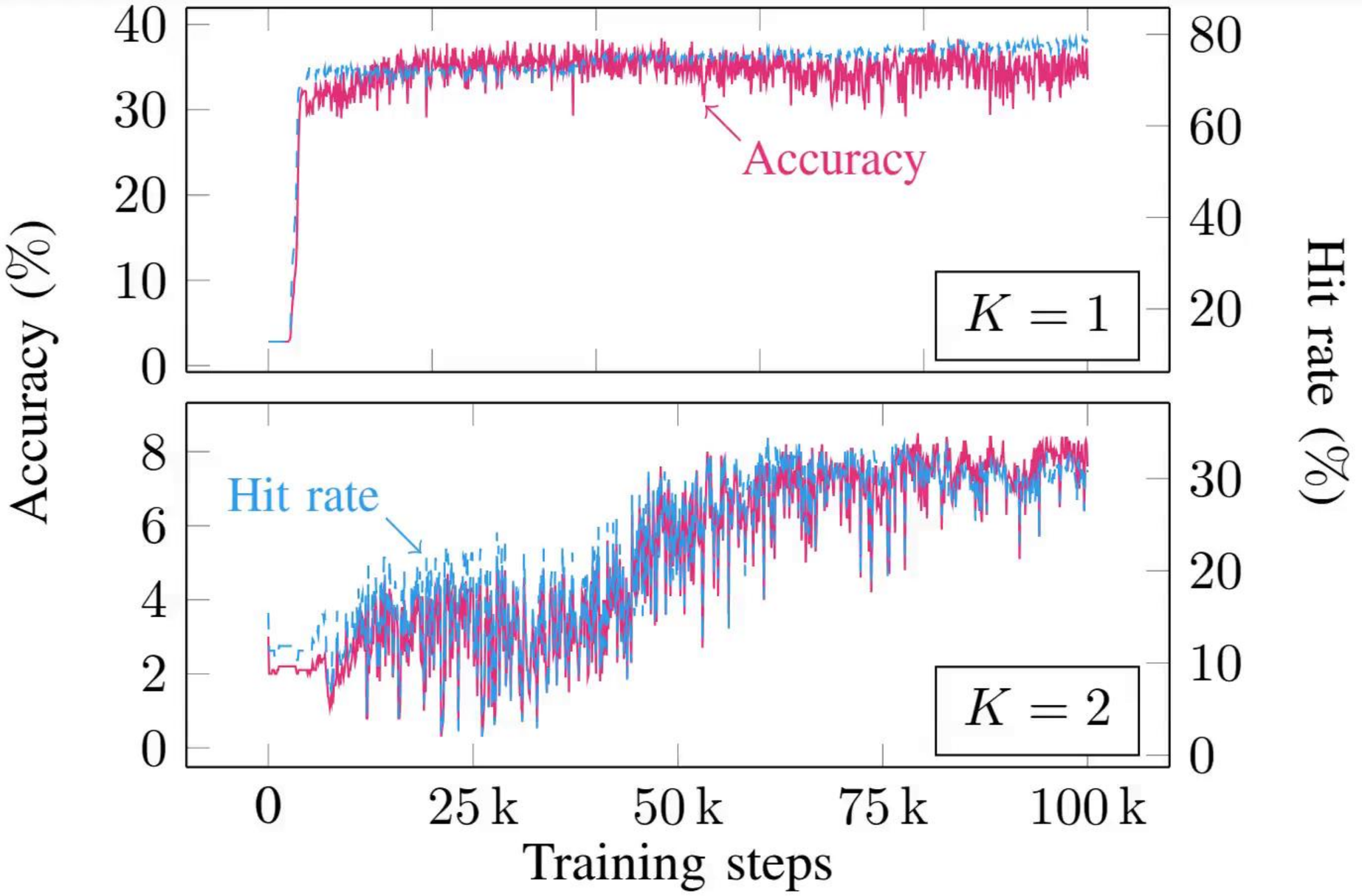
What we would like to maximise:

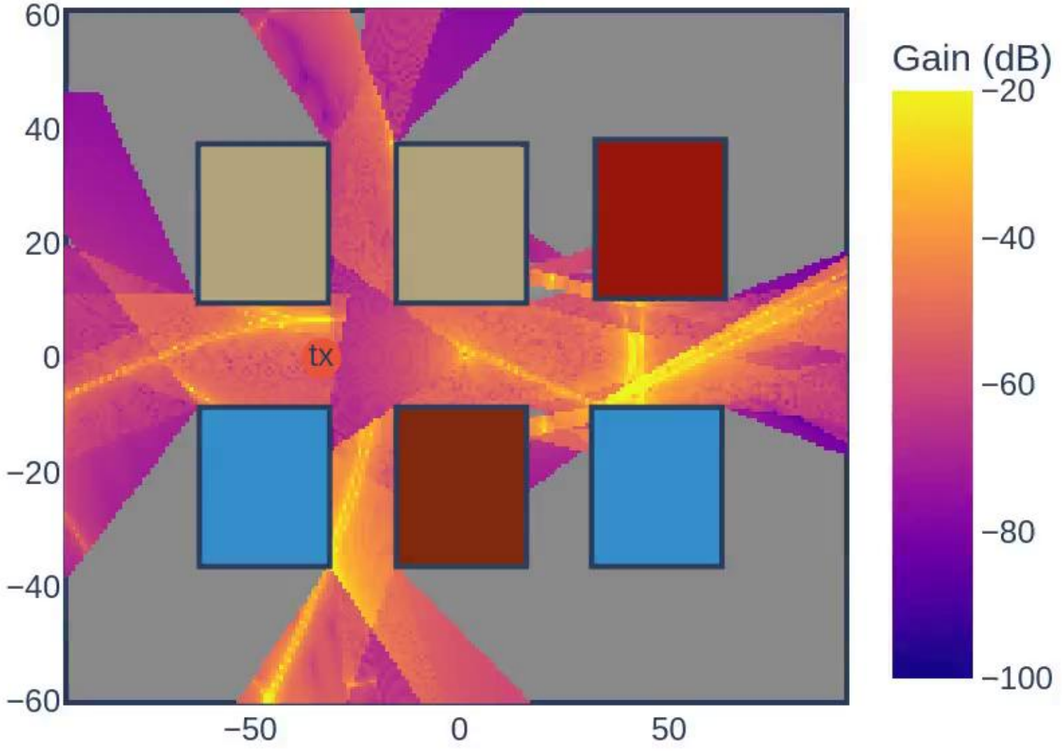
What we train on:

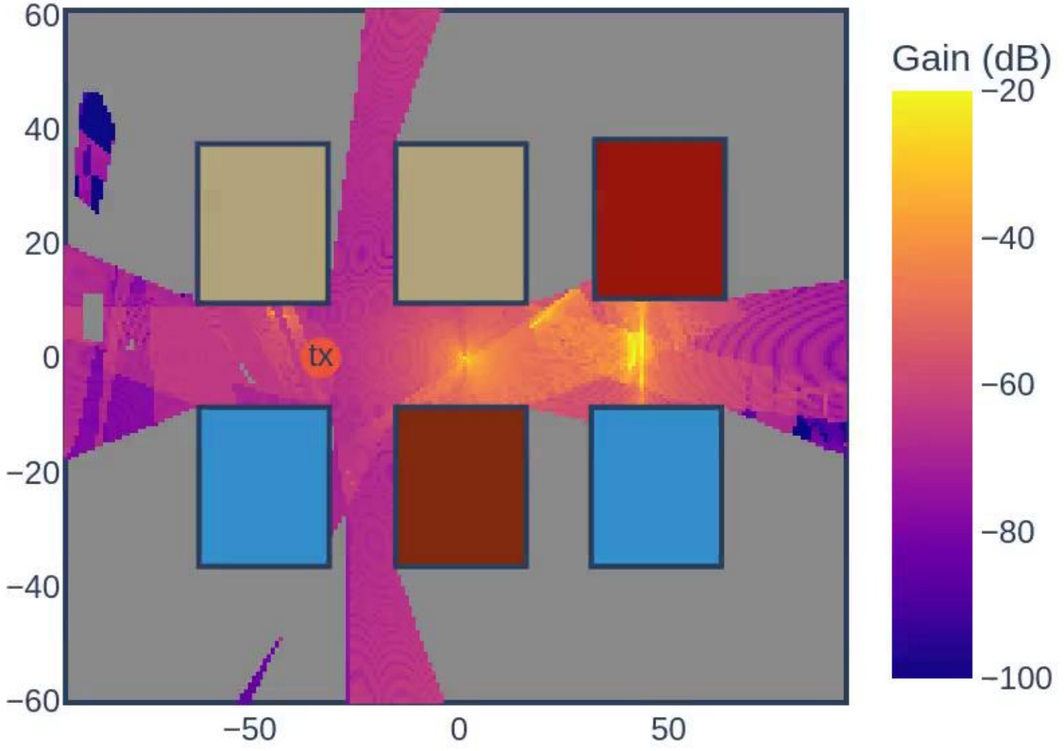
Accuracy: % of valid rays over the number of generated rays

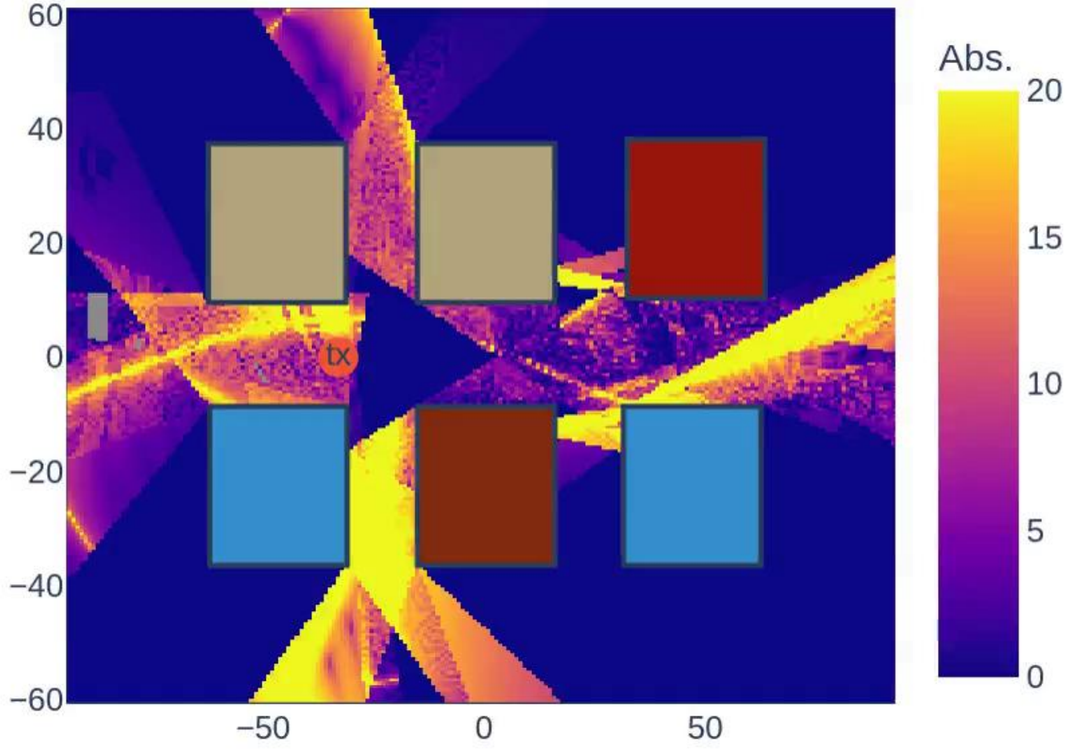
What we would like to maximise:

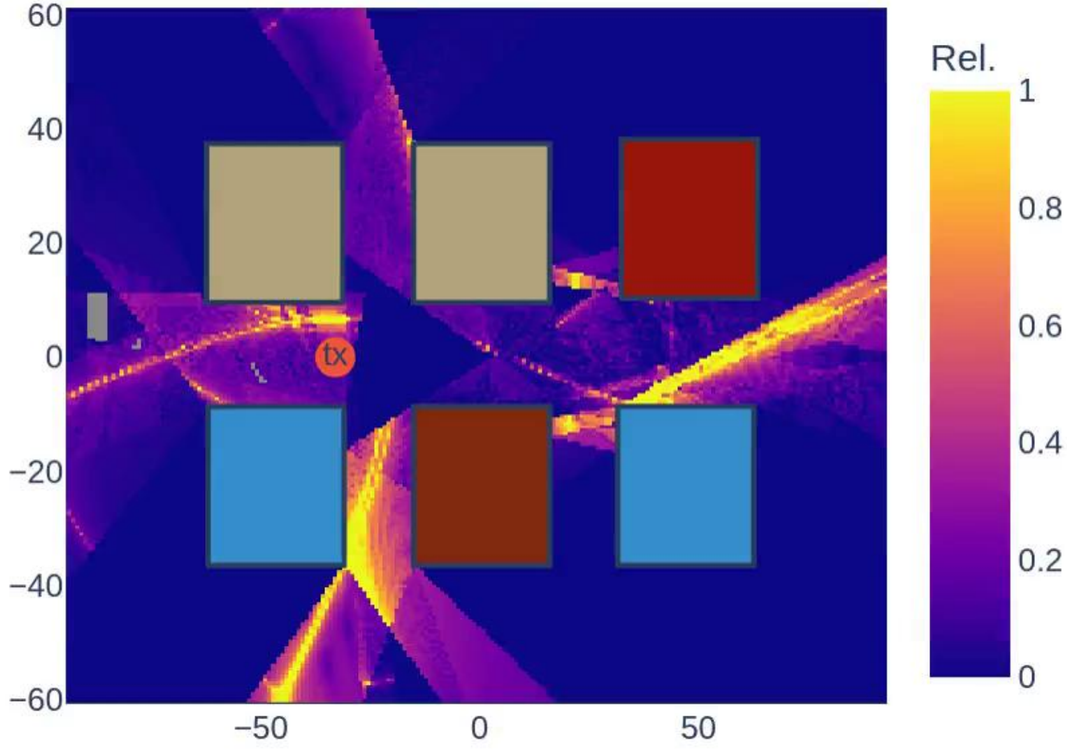
Hit rate: % of *different* valid rays found over the total number of existing valid rays


Accuracy (%)
Hit rate (%)
Accuracy
Hit rate
$K = 1$
$K = 2$
0
10
20
30
40
0
20
40
60
80
0
2
4
6
8
0
10
20
30
0
25 k
50 k
75 k
100 k
Training steps

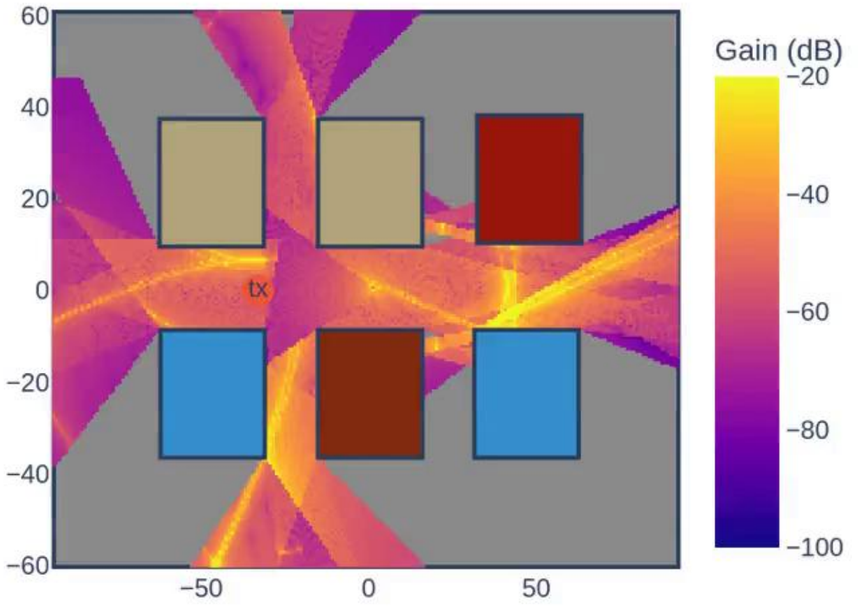

60
40
20
0
−20
−40
−60
tx
−50
0
50
Gain (dB)
−20
−40
−60
−80
−100

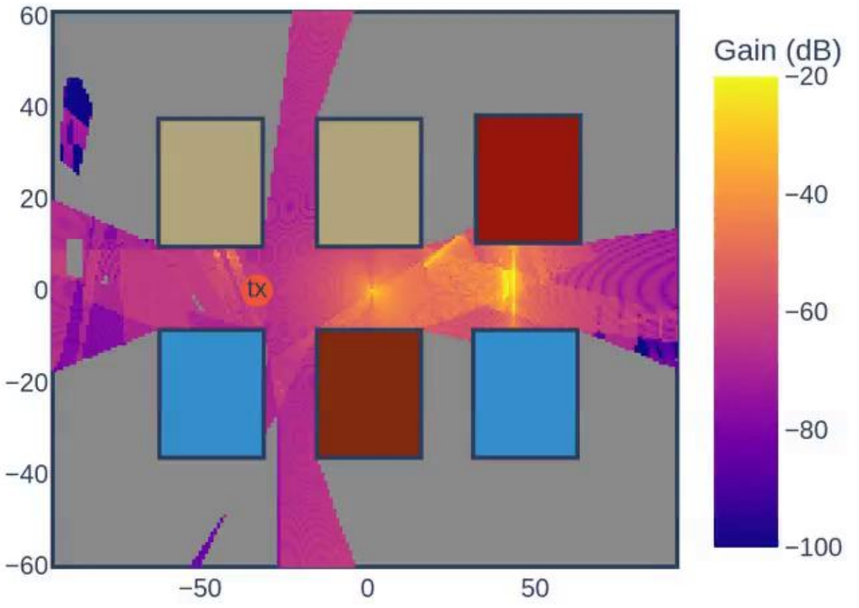

60
40
20
0
−20
−40
−60
tx
−50
0
50
Gain (dB)
−20
−40
−60
−80
−100

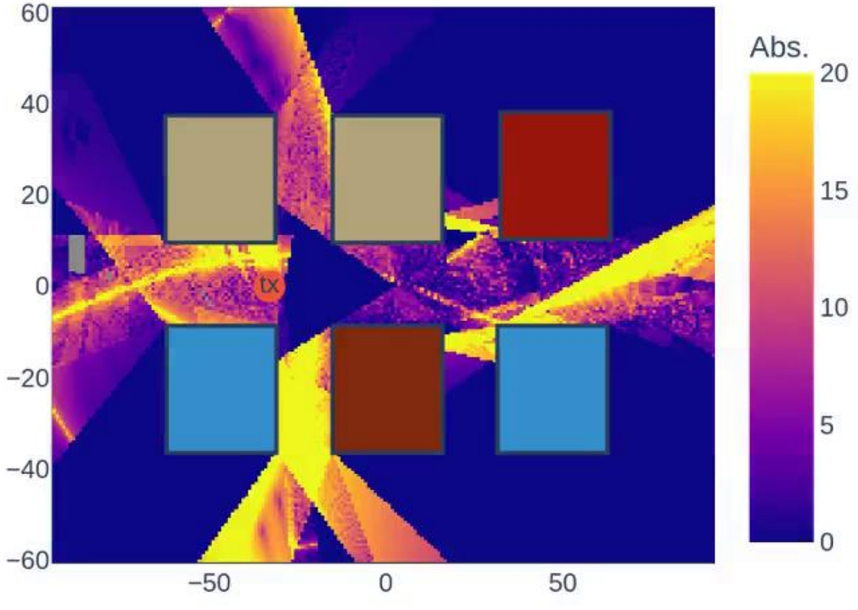


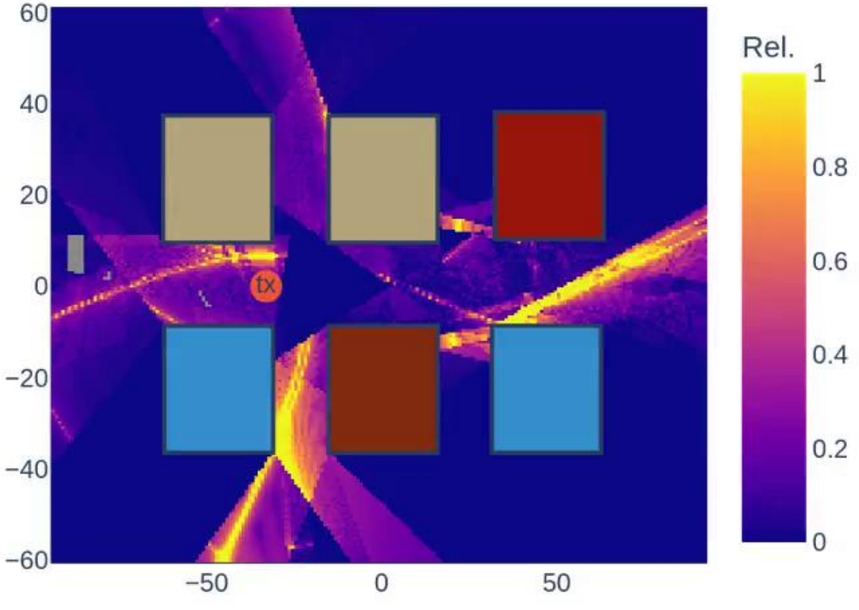


$$\delta P_{\mathrm{dB}} = 10|\log_{10}(P_{\mathrm{GT}}+\epsilon) - \log_{10}(P_{\mathrm{pred}}+\epsilon)| \quad \text{and} \quad \delta P_{\mathrm{r,dB}} = \frac{|\log_{10}(P_{\mathrm{GT}}+\epsilon) - \log_{10}(P_{\mathrm{pred}}+\epsilon)|}{|\log_{10}(P_{\mathrm{GT}}+\epsilon)|}$$


60
40
20
0
−20
−40
−60
tx
−50
0
50
Gain (dB)
−20
−40
−60
−80
−100


60
40
20
0
−20
−40
−60
tx
−50
0
50
Gain (dB)
−20
−40
−60
−80
−100


60
40
20
0
−20
−40
−60
tx
−50
0
50
Abs.
20
15
10
5
0


60
40
20
0
−20
−40
−60
tx
−50
0
50
Rel.
1
0.8
0.6
0.4
0.2
0

Summary:

Summary:

- First application of our model to EM fields prediction

Summary:

- First application of our model to EM fields prediction
- Preliminary results show a not-so-good match between hit rate and good coverage map

Summary:

- First application of our model to EM fields prediction
- Preliminary results show a not-so-good match between hit rate and good coverage map
- ML model cannot (yet) replace exhaustive RT

Summary:

- First application of our model to EM fields prediction
- Preliminary results show a not-so-good match between hit rate and good coverage map
- ML model cannot (yet) replace exhaustive RT
- EM coverage map analysis could help us improve the model