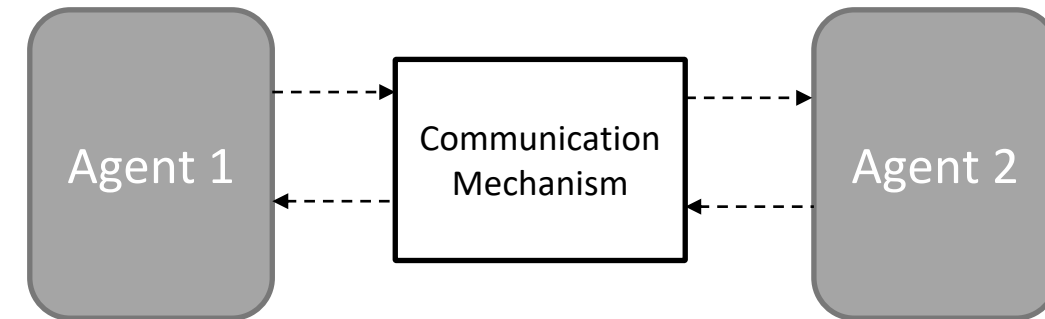# Interpretation of Emergent Communication in Heterogeneous Collaborative Embodied Agents

Shivansh Patel*, Saim Wani*, Unnat Jain*, Alexander Schwing, Svetlana Lazebnik, Manolis Savva , Angel X. Chang

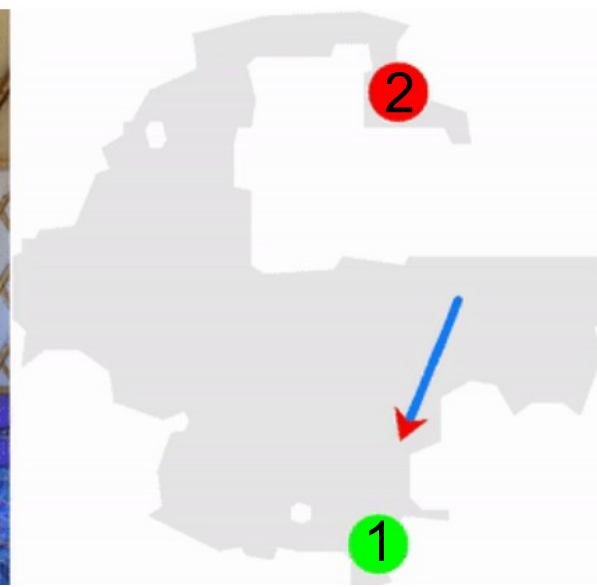http://shivanshpatel35.github.io/comon/

Contributions

1. Study different communication mechanisms in multi-agent settings
2. Interpret the studied communication mechanisms

MultiON

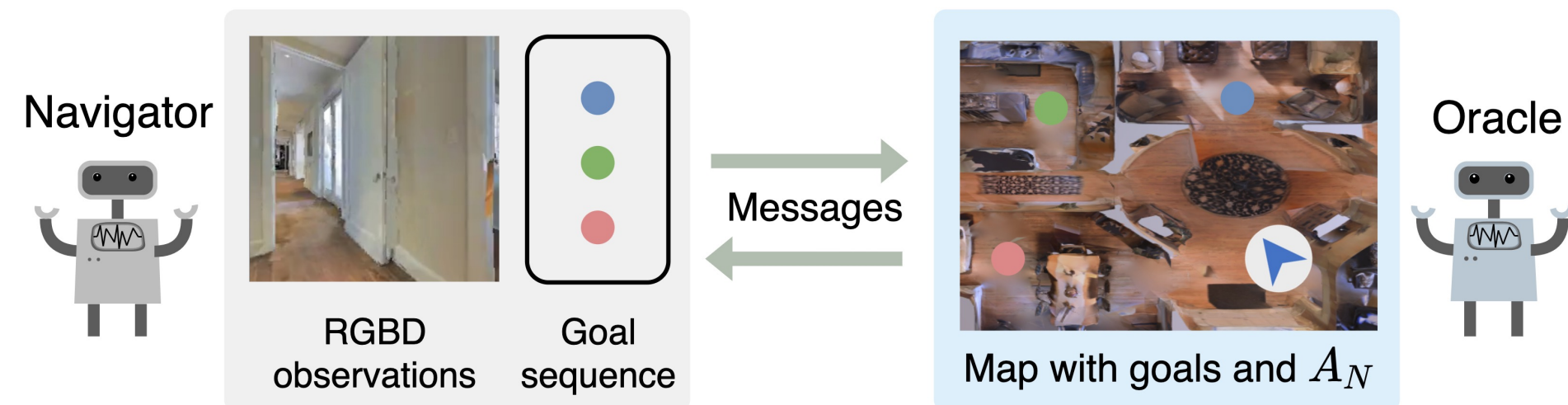Navigate to an ordered sequence of target objects placed within the environment

Input: RGBD observations and sequence of target objects

Output: actions

Assumptions: perfect localization, sensors, actuation

CoMON

Navigator — RGBD observations — Goal sequence — Messages — Map with goals and A_N — Oracle
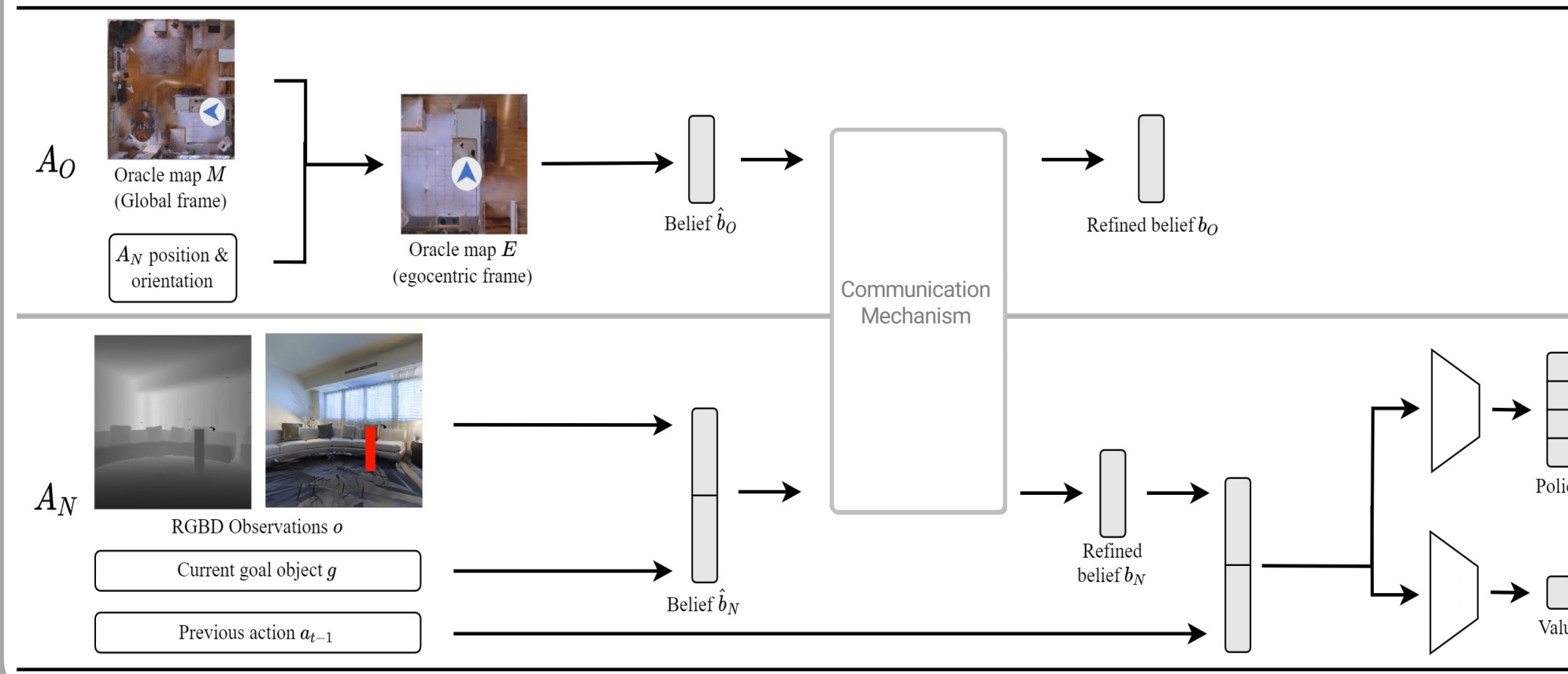
- Navigator has to navigate to a sequence of target objects
- Oracle has access to top-down map with goal locations and navigator
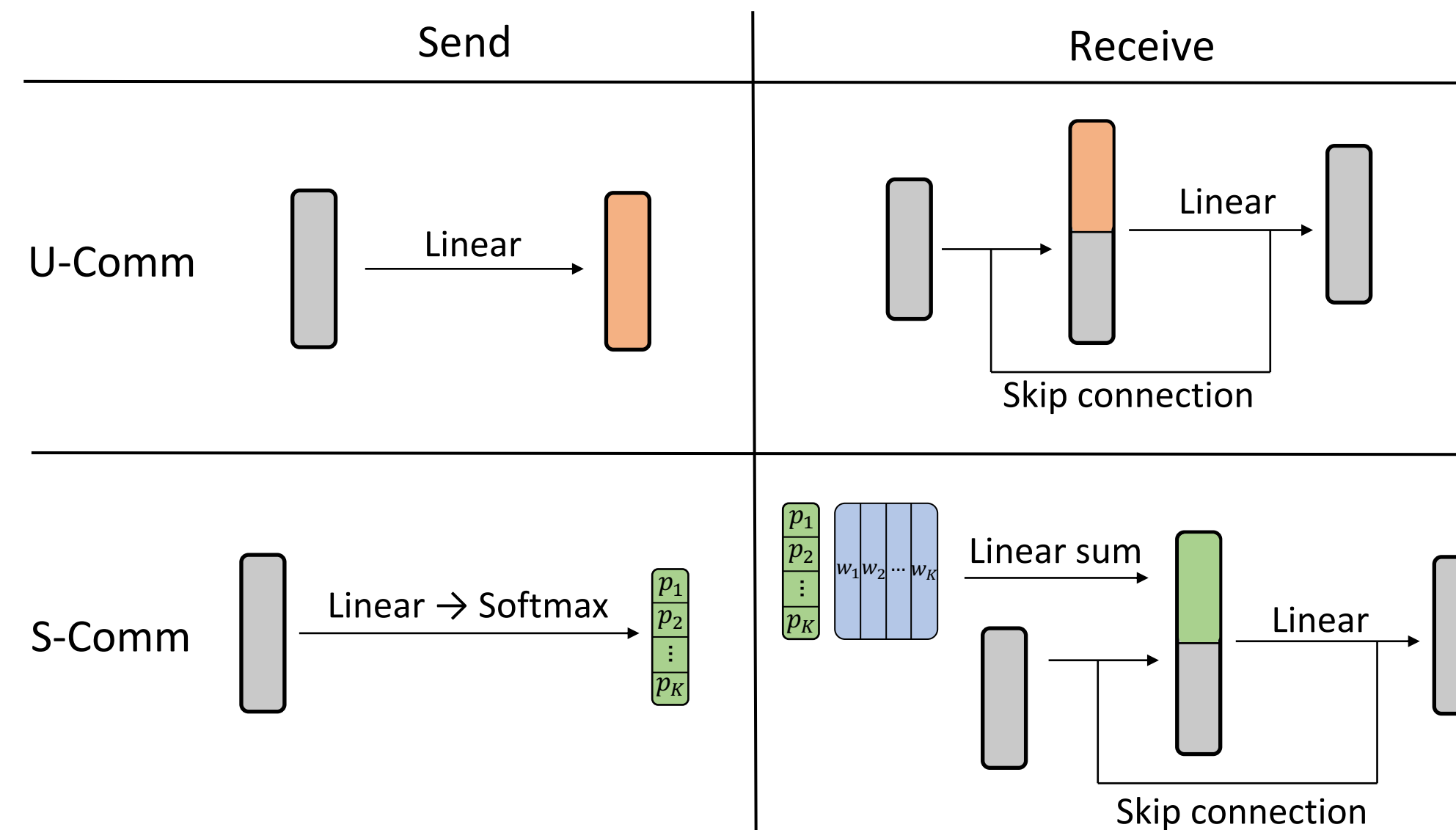- Agents can coordinate by sending messages to each other

Conclusions

- Structured communication agent outperforms unstructured communication agent in navigation
- Structured communication agent come close to matching the success rate of central agent
- Messages akin to 'I am looking for red goal' emerge
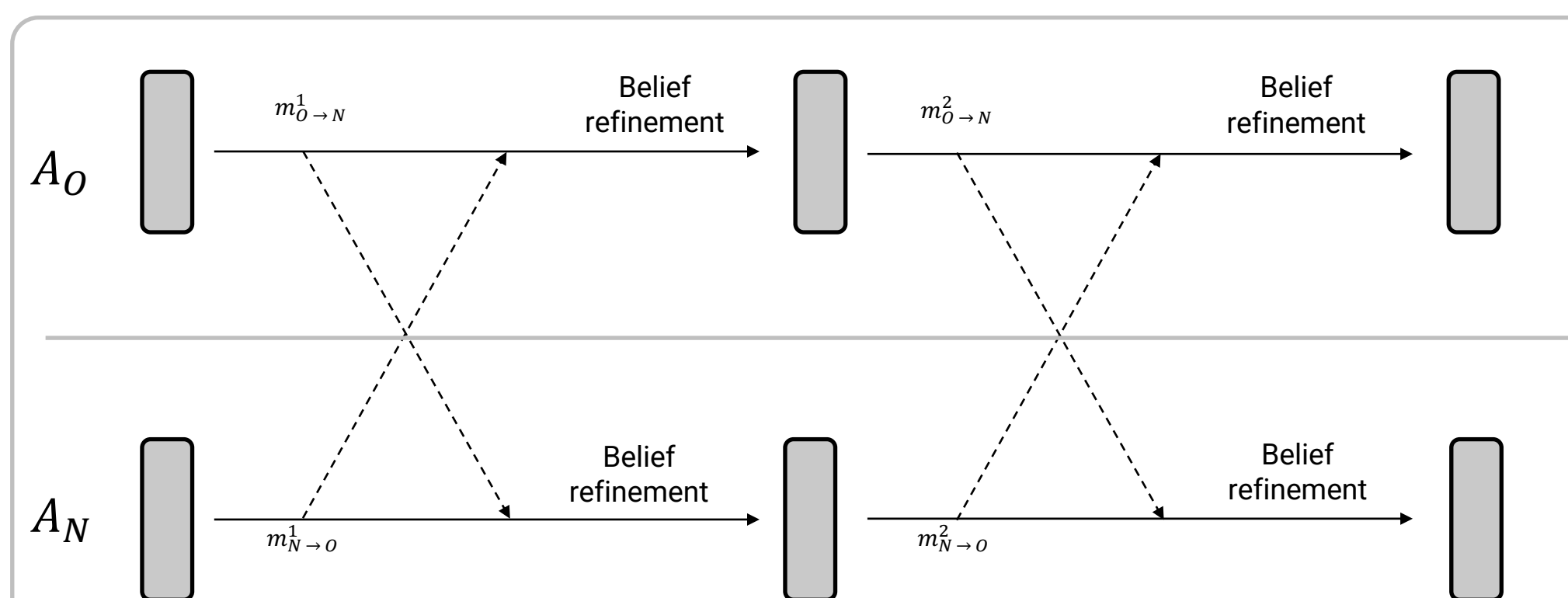- Both communication mechanisms lead to emergence of egocentrically grounded messages
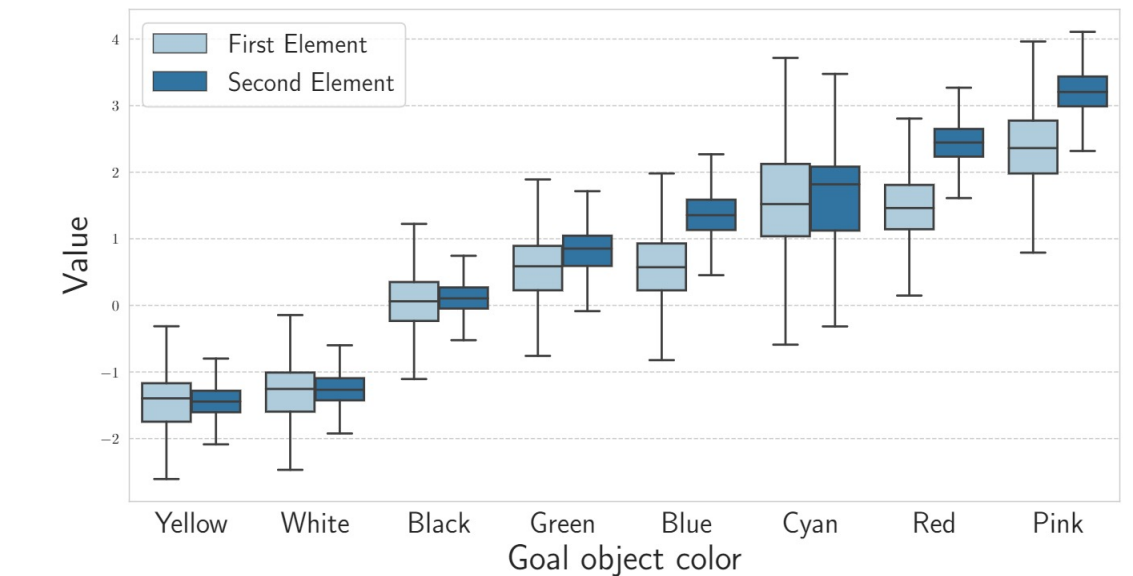
Agent Architecture

A_O — Oracle map M (Global frame) — A_N position & orientation — Oracle map E (egocentric frame) — Belief b_O — Communication Mechanism — Refined belief b_O

A_N — RGBD Observations o — Current goal object g — Previous action a_{t-1} — Belief b_N — Refined belief b_N — Policy — Value

Communication Mechanisms

	Send	Receive
U-Comm	Linear	Linear, Skip connection
S-Comm	Linear → Softmax $p_1, p_2, ..., p_K$	$w_1 w_2 ... w_K$, Linear sum, Linear, Skip connection

Messages Exchanged

A_O — $m^1_{O \to N}$ — Belief refinement — $m^2_{O \to N}$ — Belief refinement

A_N — $m^1_{N \to O}$ — Belief refinement — $m^2_{N \to O}$ — Belief refinement

U-Comm Interpretation

$m^1_{N \to O}$

$m^2_{O \to N}$

S-Comm Interpretation

Binning of probabilities

$m^1_{N \to O}$
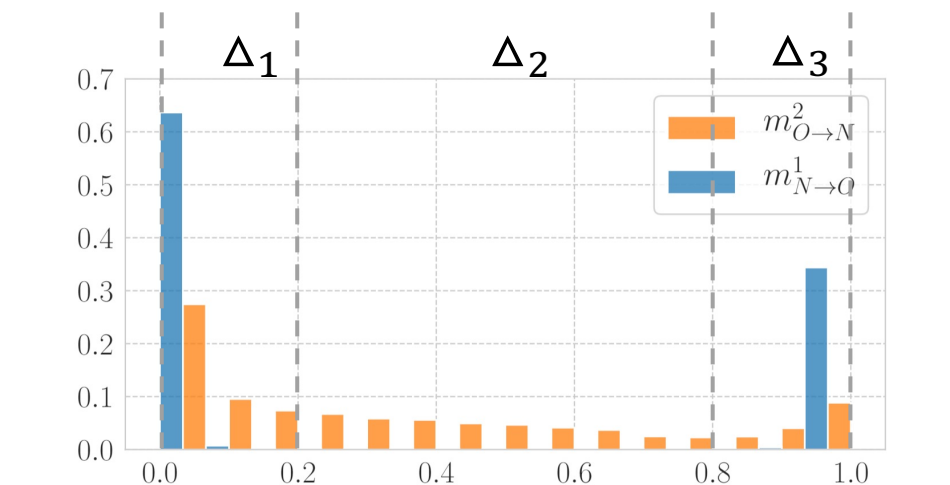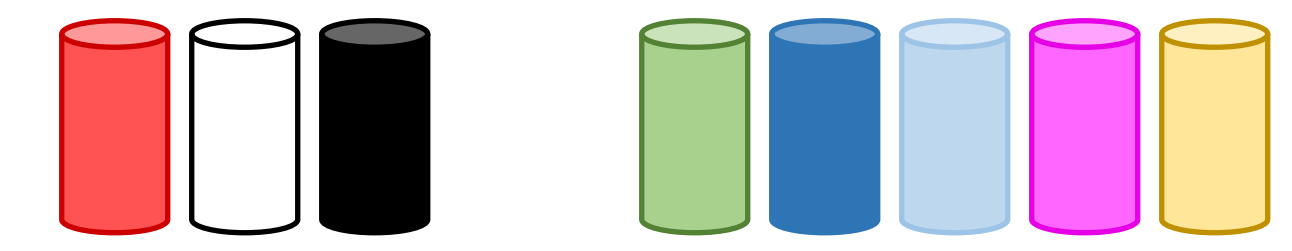
$m^2_{O \to N}$
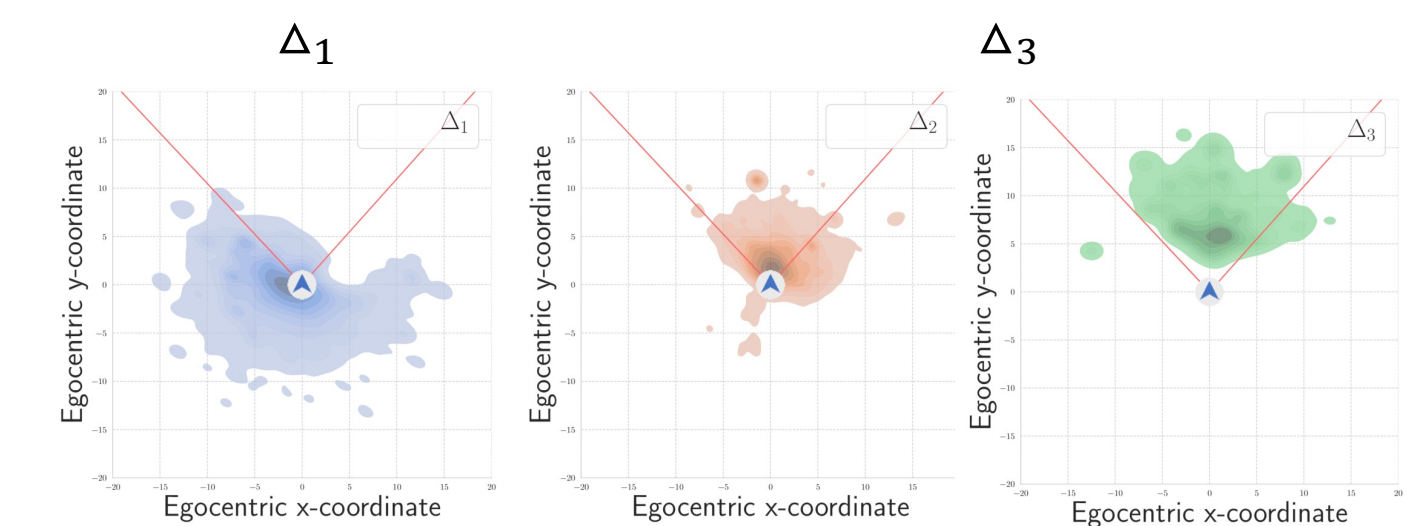
Quantitative Results

	Progress (%)			PPL (%)		
	1-ON	2-ON	3-ON	1-ON	2-ON	3-ON
U-Comm	**87**	77	63	60	51	39
S-Comm	85	**80**	**70**	**67**	**59**	**50**
OracleMap	89	80	70	74	64	52