

Controlling steering with Energy-Based Models

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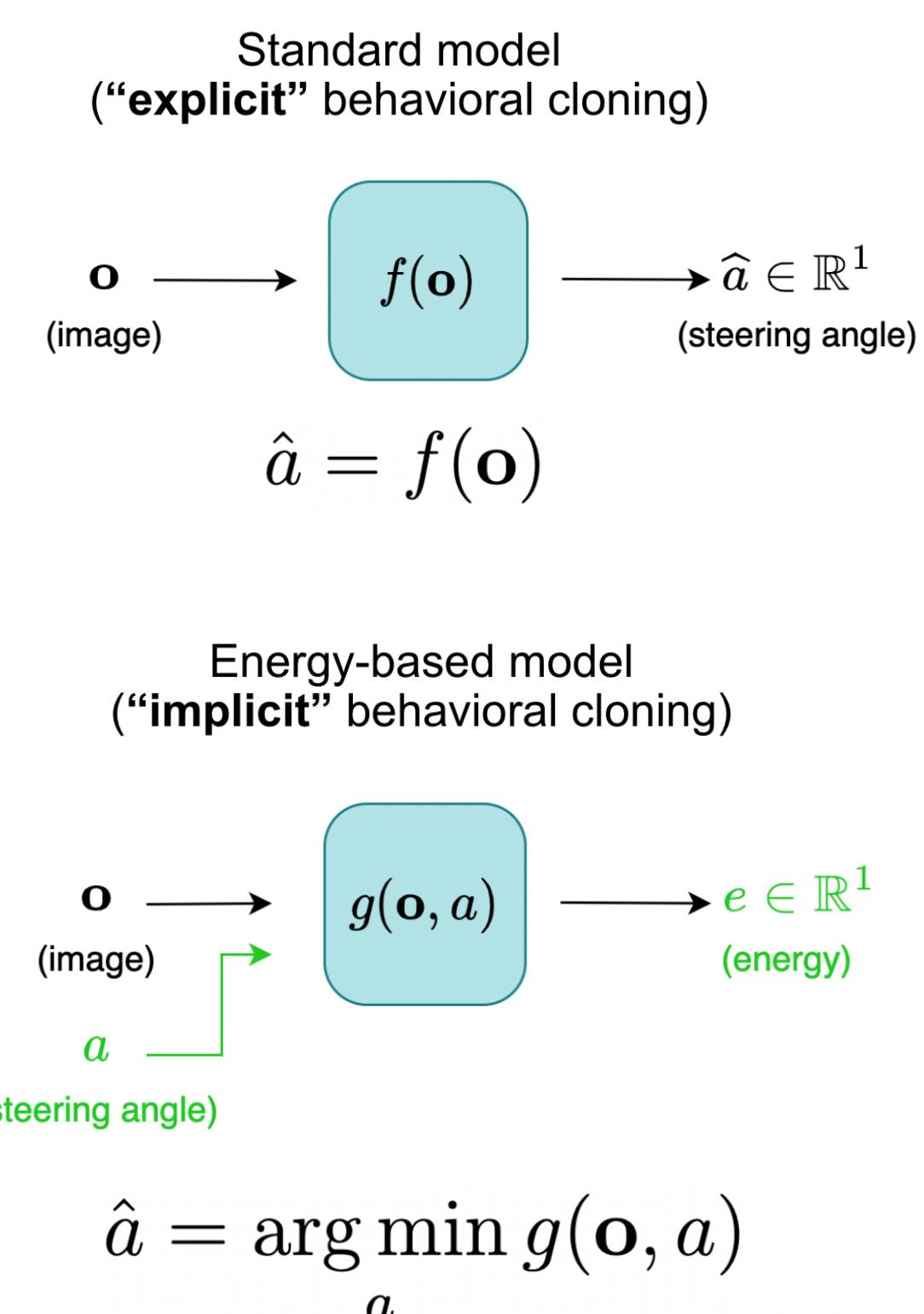
We tested energy-based models at rally road-following with a real car.



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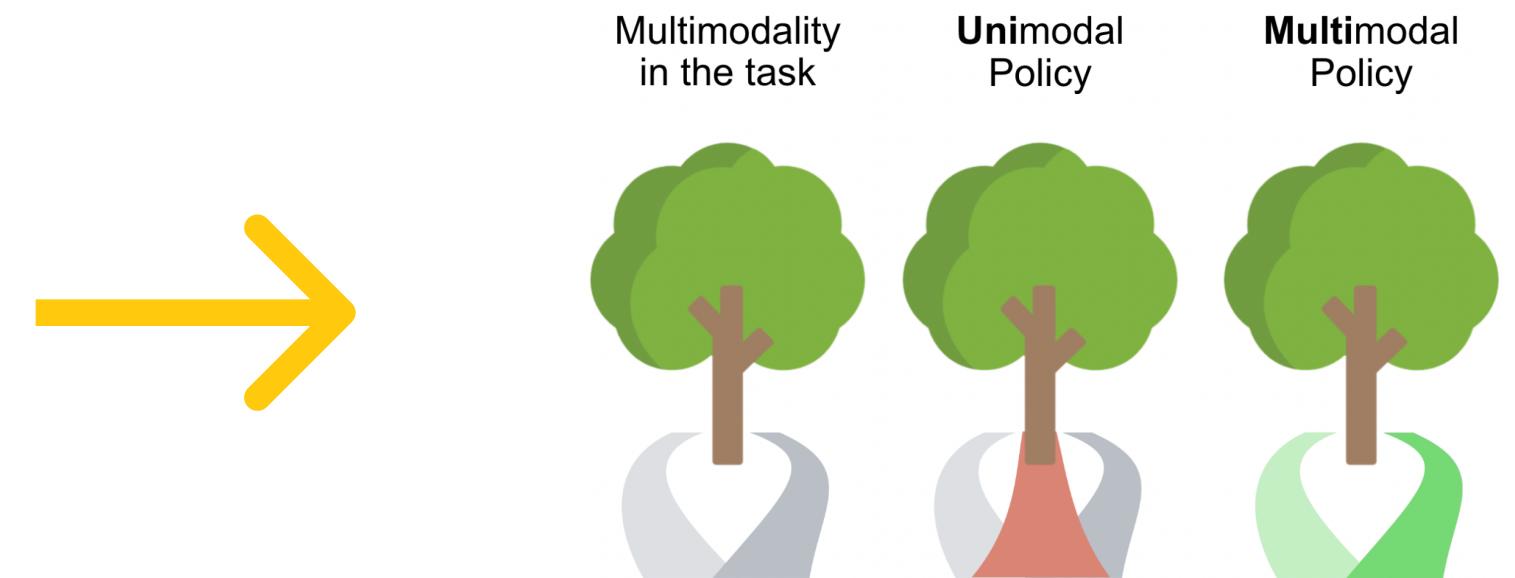
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What is Energy-based



What we thought

- 1 Standard PilotNet would **do this**
- 2 Energy-based PilotNet would **do this**
- 3 Energy-based → fewer interventions



What happened

- 1 Standard PilotNet **did a lot of this (89%)** - expected!
- 2 Energy-based **did mostly this (61%)** - great!
- 3 Energy-based → ~same # interventions - *oh :)*
- 4 Energy-based → less smooth - *can we fix?*



What we tried

- 1 Soft targets in the cross-entropy loss
- 2 Temporal smoothing loss term (see formula →)

$$L_{temp} = \alpha \|\mathbf{e}_t - \mathbf{e}_{t+1}\|,$$

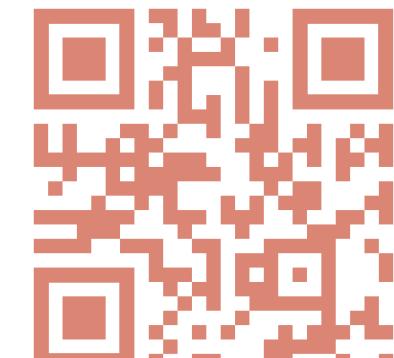
\mathbf{e}_t : energies of all possible angles at time t
 α : smoothing strength (e.g. 1.0)

Replicate our results!

OR use this as a benchmark

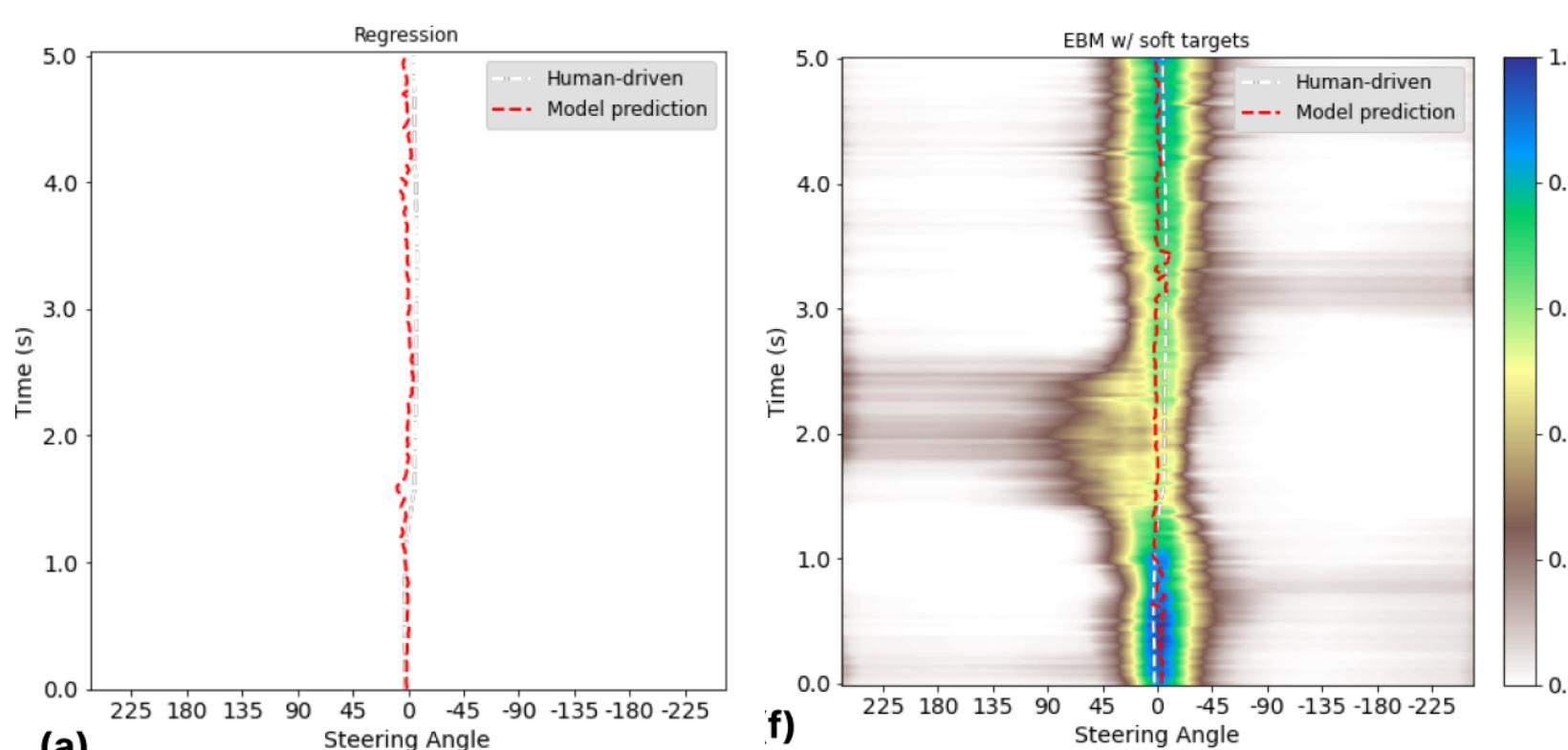
OR to select models you deploy

THE SIMULATOR



Code to evaluate models on our real-world track in the VISTA Driving Simulator

Extra figures



Model predictions over a 5-sec intersection from above. Energy-Based PilotNet can model multimodalities (left turn @2s and right @3.5s). Standard (MAE regression) PilotNet cannot, because it is unimodal.

Driving ability over three real-world and three VISTA drives per model

Model	Real world		VISTA	
	Interventions	Whiteness	Crashes	Whiteness
EBM	4	176.93°/s	2	114.33°/s
	1	96.94°/s	1	121.57°/s
	2	223.59°/s	2	121.67°/s
EBM Temp. Smoothing	mean: 2.33	165.82°/s	1.67	119.19°/s
	5	119.39°/s	3	58.70°/s
	2	137.22°/s	2	60.37°/s
EBM Soft Targets	3	77.28°/s	2	48.86°/s
	mean: 3.33	111.30°/s	2.33	55.98°/s
	5	56.33°/s	3	85.72°/s
Regression (MAE)	5	57.15°/s	3	74.97°/s
	4	56.86°/s	3	81.87°/s
	mean: 4.66	56.78°/s	3	80.85°/s
Classification	2	37.84°/s	0	24.39°/s
	2	75.34°/s	0	24.75°/s
	1	33.10°/s	0	24.25°/s
MDN	mean: 1.66	48.76°/s	0	24.47°/s
	1	182.39°/s	1	123.69°/s
	7	287.14°/s	1	105.13°/s
	1	162.27°/s	1	104.31°/s
	mean: 3.00	210.60°/s	1	111.04°/s
	5	33.62°/s	3	37.22°/s
	5	35.46°/s	3	35.74°/s
	5	37.39°/s	3	35.84°/s
	mean: 3.66	35.49°/s	3	36.27°/s