Controlling steering with Energy-Based Models

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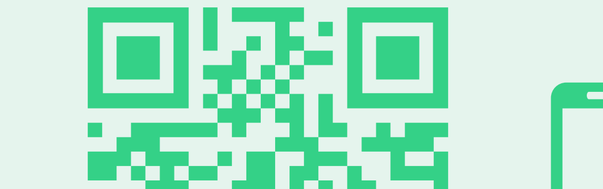
We tested **energy-based** models at rally road-following with a **real car**.

Take a picture to:

- get the full paper
- get this poster

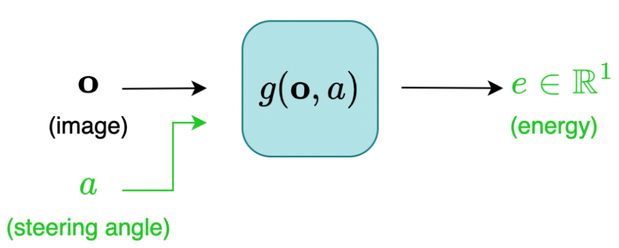
What is Energy-based

Standard model
(**"explicit"** behavioral cloning)



$$\hat{a} = f(\mathbf{o})$$

Energy-based model
(**"implicit"** behavioral cloning)



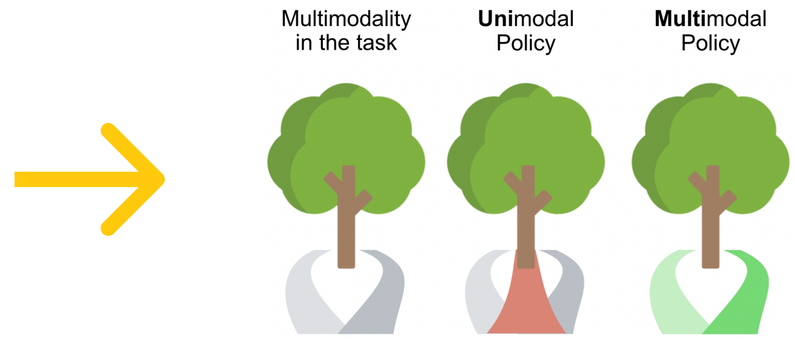
$$\hat{a} = \arg\min_{a} g(\mathbf{o}, a)$$

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 *(see results in the paper)*

1 Soft targets in the cross-entropy loss

2 Temporal smoothing loss term (see formula →)

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

$\mathbf{e}_t$: energies of all possible angles at time *t*

α : smoothing strength (e.g. *1.0*)

Replicate our results!

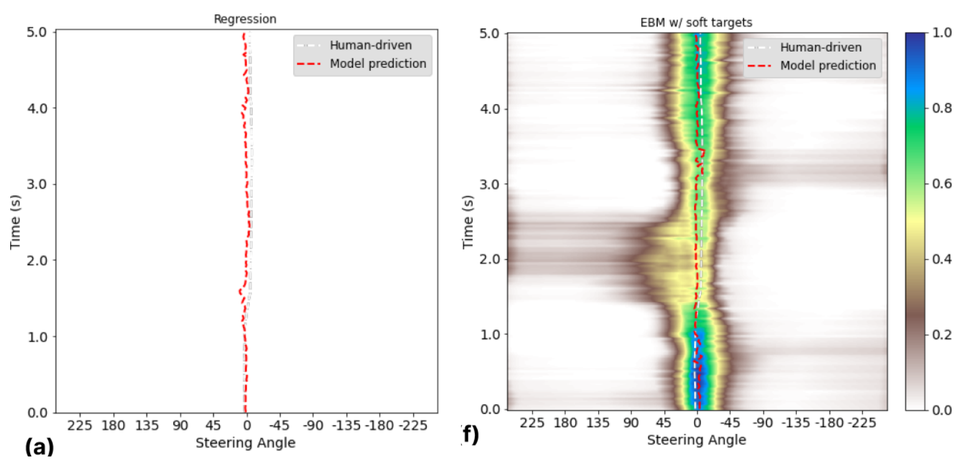
OR use this as a benchmark

OR to select models you deploy

THE VISTA 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 Interventions	Real world Whiteness	VISTA Crashes	VISTA 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
mean:	2.33	165.82°/s	1.67	119.19°/s
EBM Temp. Smoothing	5	119.39°/s	3	58.70°/s
	2	137.22°/s	2	60.37°/s
	3	77.28°/s	2	48.86°/s
mean:	3.33	111.30°/s	2.33	55.98°/s
EBM Soft Targets	5	56.33°/s	3	85.72°/s
	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
Regression (MAE)	2	37.84°/s	0	24.39°/s
	2	75.34°/s	0	24.75°/s
	1	33.10°/s	0	24.25°/s
mean:	1.66	48.76°/s	0	24.47°/s
Classification	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
MDN	1	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