

Curvy DeepPicar

Using Bèzier Curves Scheduling Steering Control

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DeepPicar

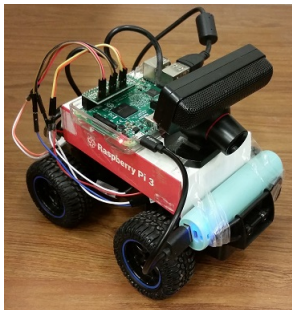


Figure: DeepPicar Vehicle [1]

DeepRacing

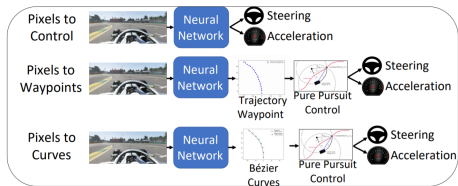


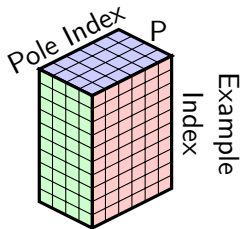
Figure: Overview of CNN control schemes [2]

Bèzier Loss Function

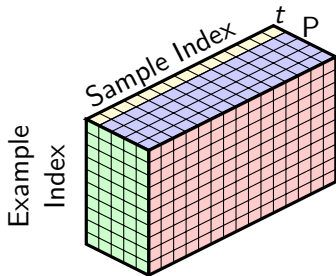
$$B(t) = \sum_{k=0}^n \binom{n}{k} (1-t)^{n-k} t^k P_k \quad t \in [0, 1]$$

Matrix Form from [2]: $B(t) = A(t, n)P$

Model Output



Actual Output



DeepPicar Dataset

Image and point pair at every 0.05 seconds/50 milliseconds/20Hz and labeled incorrectly as microseconds in data. Using a moving average filter to approximate continuous control inputs.

Table: Output Data from Video 1

Time [ms]	Frame	Wheel Angle [rad]
1527606810546	30	0
1527606810596	31	0
1527606810646	32	0
1527606810696	33	0
1527606810746	34	0
1527606810796	35	0.523598776
1527606810846	36	0.523598776
1527606810896	37	0.523598776
1527606810946	38	0.523598776
1527606810996	39	0.523598776
1527606811046	40	0.523598776
1527606811096	41	0.523598776
1527606811146	42	0
1527606811196	43	0
1527606811246	44	0
1527606811296	45	0
1527606811346	46	0
1527606811396	47	0

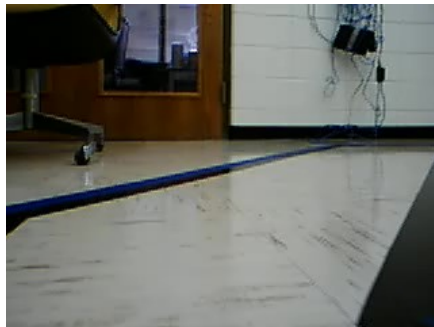


Figure: Example Image from Video 1[1]

Training the Networks

- Train on 9 of 11 videos.
- Train on only 200 of 1000 images of a video at once. Horizontally flip the image as well.
- 80-20 Test Validation split.
- Train 50 epochs every 200 frames and loop over videos a total of 4 times.
- Bèzier CNN is 2 Hz controller over 0.2 seconds with 3rd degree polynomial.

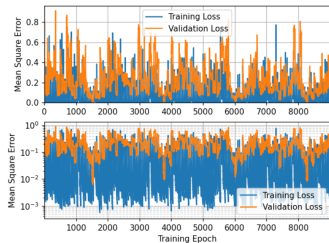


Figure: DAVE-2 CNN Training History

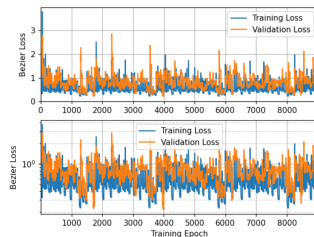


Figure: Bèzier CNN Training History

Accuracy Results

Table: Image-to-Point CNN Model (Acc: 20.45%)

		Model Predicted		
		Left	Center	Right
Record	Left	48	31	21
	Center	156	156	188
	Right	54	136	205

Results based on 2 unseen test files (2000 images total). Note not there is a bias in the dataset for right turns and just going straight is correct 50% of the time.

Table: Image-to-Point Bèzier Model (Acc: 66.75%)

		Model Predicted		
		Left	Center	Right
Record	Left	60	111	9
	Center	48	667	261
	Right	13	223	608

Table: Image-to-Curve Bèzier Model (Acc; 38.10%)

		Model Predicted		
		Left	Center	Right
Record	Left	83	46	33
	Center	268	343	313
	Right	177	268	336

To the videos!

- [1] M. G. Bechtel, E. McElhiney, M. Kim, and H. Yun, “Deeppicar: A low-cost deep neural network-based autonomous car,” in *IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA)*, 2018.
- [2] T. Weiss and M. Behl, “Deepracing: Parameterized trajectories for autonomous racing,” *CoRR*, vol. abs/2005.05178, 2020. [Online]. Available: <https://arxiv.org/abs/2005.05178>