

# Test-Time Perturbation Tuning with Delayed Feedback for Vision-Language-Action Models

## Supplementary Material

### 6. Psydo-Code

We provide a brief overview of the training pipeline outlined in Algorithm 1, which implements PDF.

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**Algorithm 1** Perturbation Learning with Delayed Feedback (PDF)

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**Require:** Pretrained VLA parameters  $\phi$  (frozen); Perturbation head parameters  $\theta$  (trainable); maximum augmentation budget  $N_{\max}$ ; buffer  $\mathcal{D}$ .

- 1: **for** each episode **do**
- 2:   **for** each timestep  $t$  **do**
- 3:     Observe current state  $s_t = (o_t, c_t)$
- 4:     Embed  $o_t$  and  $c_t$  to obtain multimodal feature  $f_t$
- 5:     Compute logits  $z_t = h_\phi(f_t)$
- 6:     Estimate uncertainty by Equation 1
- 7:     Determine augmentation budget  $N_t = N_{\max} \cdot \mathcal{U}_t$
- 8:     Generate augmented views  $\{T_j(o_t)\}_{j=1}^{N_t}$
- 9:     **for** each view  $T_j(o_t)$  **do**
- 10:       Encode to feature  $f_{t,j}$
- 11:       Compute perturbed logits by Equation 3
- 12:     **end for**
- 13:     Select final action  $a_t$  by majority voting over  $\tilde{z}_{t,j}$
- 14:     Interact with environment using  $a_t$
- 15:     Store  $\{f_{t,j}\}$  in buffer  $\mathcal{D}$
- 16:   **end for**
- 17:   Receive delayed feedback  $r$  after episode
- 18:   Sample batch of features  $f_b$  from  $\mathcal{D}$
- 19:   Compute perturbed logits  $\tilde{z}_b = h_\phi(f_b) + h_\theta(f_b)$
- 20:   Generate policy  $\tilde{\pi}_b = \text{softmax}(\tilde{z}_b)$
- 21:   Compute PDF loss by Equation 5
- 22:   Update perturbation head  $\theta \leftarrow \theta - \eta \nabla_\theta \mathcal{L}_{\text{PDF}}$
- 23: **end for**

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### 7. Additional Experiments Results on Atari 57

Table 4 presents the detailed results of PDF and JAT on the full Atari 57 benchmark.

Games	ID	JAT (Raw Score)	JAT (Human Normalized Score)	PDF (Raw Score)	PDF (Human Normalized Score)
ALIEN	22	1427.9 ± 540.28	0.17	2034.4 ± 560.47	0.26
AMIDAR	34	105 ± 76.93	0.06	150.2 ± 57.05	0.08
ASSAULT	4	1627.57 ± 799.09	2.7	1861 ± 742.69	3.15
ASTERIX	51	861.5 ± 517.97	0.08	700 ± 361.25	0.06
ASTEROIDS	42	1362 ± 461.03	0.01	1405 ± 241.92	0.01
ATLANTIS	3	47047 ± 102148.27	2.11	54950 ± 12497.3	2.6
BANKHEIST	38	972.6 ± 139.62	1.3	976 ± 109.01	1.3
BATTLEZONE	57	17660 ± 6516.47	0.47	13700 ± 5348.83	0.36
BEAMRIDER	48	757.76 ± 297.41	0.02	704.4 ± 250.38	0.02
BERZERK	23	692.3 ± 337.1	0.23	910 ± 160.93	0.31
BOWLING	37	22.48 ± 5.71	0	24.1 ± 5.72	0.01
BOXING	1	92.77 ± 12.05	7.72	100 ± 22.36	8.33
BREAKOUT	52	8.77 ± 5.81	0.25	8.2 ± 4.53	0.23
CENTIPEDE	24	5807.4 ± 2289.32	0.37	6599.8 ± 3203.28	0.45
CHOPPERCOMMAND	10	2448 ± 1351.18	0.25	3820 ± 1116.06	0.46
CRAZYCLIMBER	11	100385 ± 23988.53	3.58	104930 ± 23118.83	3.76
DEFENDER	6	38731 ± 13137.38	2.27	44910 ± 19215.64	2.66
DEMONATTACK	17	817.2 ± 1218.2	0.37	1031 ± 268.88	0.48
DOUBLEDUNK	28	15.88 ± 8.9	0.99	17.6 ± 8.49	1.03
ENDURO	49	109.9 ± 27.42	0.13	104.4 ± 23.25	0.12
FISHINGDERBY	50	-28.9 ± 23.1	0.48	-30 ± 14.18	0.47
FREEWAY	18	27.37 ± 1.85	0.92	30.8 ± 1.47	1.04
FROSTBITE	9	2818.1 ± 1637.63	0.64	3785 ± 861.11	0.87
GOPHER	16	5996.6 ± 2928.52	2.66	6302 ± 3369.31	2.8
GRAVITAR	47	1340.5 ± 890.97	0.37	1340 ± 912.63	0.37
H.E.R.O.	29	12735.4 ± 3712.12	0.39	14048.5 ± 2446.9	0.44
ICEHOCKEY	5	7.21 ± 5.23	1.52	12.5 ± 5.78	1.96
JAMESBOND	55	370.5 ± 242.08	1.25	360 ± 106.77	1.21
KANGAROO	35	441 ± 353.01	0.13	500 ± 223.61	0.15
KRULL	8	10618.1 ± 1301.69	8.45	10957 ± 1389.92	8.77
KUNG-FUMASTER	43	255 ± 209.46	0	270 ± 195.19	0
MONTEZUMA'SREVENGE	44	0 ± 0	0	0 ± 0	0
MS.PACMAN	12	1538.8 ± 391.43	0.19	2609 ± 525.12	0.35
NAMETHISGAME	7	7679 ± 2462	0.94	9665 ± 2009.26	1.28
PHOENIX	20	1963.9 ± 1487.39	0.19	2548 ± 2296.47	0.28
PITFALL	40	-25.24 ± 199.07	0.03	-3.5 ± 8.96	0.03
PONG	15	13.32 ± 13.31	0.96	18.4 ± 7.8	1.11
PRIVATEEYE	46	42 ± 49.36	0	40 ± 48.99	0
Q*BERT	21	2190.75 ± 2789.24	0.15	3387.5 ± 3334.39	0.24
RIVERRAID	31	3780.1 ± 1494.42	0.15	4311 ± 2066.83	0.19
ROADRUNNER	26	5409 ± 4063.84	0.69	5930 ± 6188.06	0.76
ROBOTANK	19	9.8 ± 4.29	0.78	10.7 ± 4.54	0.88
SEAQUEST	39	856.2 ± 345.1	0.02	1002 ± 302.85	0.02
SKIING	25	-17007.41 ± 6176.5	0.01	-16110.9 ± 6255.6	0.08
SOLARIS	54	1300.4 ± 434.15	0.01	1024 ± 360.98	-0.02
SPACEINVADERS	32	352.95 ± 198.67	0.13	396 ± 141.93	0.16
STARGUNNER	30	4698 ± 3102.48	0.42	5100 ± 4481.52	0.46
SURROUND	53	3.57 ± 4.2	0.82	3.2 ± 3.82	0.8
TENNIS	56	-11.9 ± 4.57	0.37	-13.3 ± 5.06	0.33
TIMEPILOT	2	11830 ± 4266.79	4.97	12710 ± 4073.68	5.5
TUTANKHAM	14	110.42 ± 65.31	0.63	133.1 ± 59.05	0.78
UPANDDOWN	13	19616.9 ± 10519.15	1.71	21370 ± 6814.47	1.87
VENTURE	45	0 ± 0	0	0 ± 0	0
VIDEOPINBALL	33	12522.37 ± 9866.3	0.71	13017.3 ± 4473.44	0.74
WIZARDOFWOR	27	2228 ± 2246.38	0.4	2470 ± 2106.68	0.45
YARSREVENGE	36	11192.57 ± 6595.92	0.16	12064.7 ± 8045.11	0.17
ZAXXON	41	7033 ± 3261.04	0.77	7060 ± 2196	0.77
Average	-	-	0.97	-	1.07

Table 4. Performance evaluations on 57 Atari games.