

Physiology-augmented multivariate temporal learning for adaptive simulation of electrical excitation in cardiac myocytes

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Table A1 Components of cellular physiological state.

Abbreviation	Physiological attribute
V	membrane voltage
Na _i	the intracellular sodium (Na _i) concentrations
K _i	the intracellular potassium (K _i) concentrations
Ca _i	the free cytoplasmic Ca ²⁺ concentration
Ca _{ss}	the free diadic subspace Ca ²⁺ concentration
Ca _{sr}	the free sarcoplasmic reticulum Ca ²⁺ concentration
INa	fast Na ⁺ current
ICaL	L-type Ca ²⁺ current
Ito	transient outward current
IKs	slow delayed rectifier current
IKr	rapid delayed rectifier current
IK1	inward rectifier K ⁺ current
INaCa	Na ⁺ /Ca ²⁺ exchanger current
INaK	Na ⁺ /K ⁺ pump current
IpCa	sarcolemmal Ca ²⁺ pump current
IpK	plateau K ⁺ current
IbNa	background K ⁺ current
IbCa	background Ca ²⁺ current

Table A2 Contents of different pacing protocols

	Protocol type	Content of the protocol
Normal condition	S1-S2 protocol	An S2 stimulus is applied after every 10 times of S1 stimulation at 1 Hz frequency, totaling 45 types of S1-S2 intervals.
	Dynamic protocol	After every 10 times stimuli, the frequency will be reduced once, for a total of 40 types of stimulus frequencies.
Pathological condition	Uniform protocol	A total of 11 stimulus frequencies are available, each of which is stimulated 50 times consecutively.
	S1-S2 protocol	An S2 stimulus is applied after every 10 times of S1 stimulation at 1 Hz frequency, totaling 45 types of S1-S2 intervals.
	Dynamic protocol	After every 10 times stimuli, the frequency will be reduced once, for a total of 40 types of stimulus frequencies.

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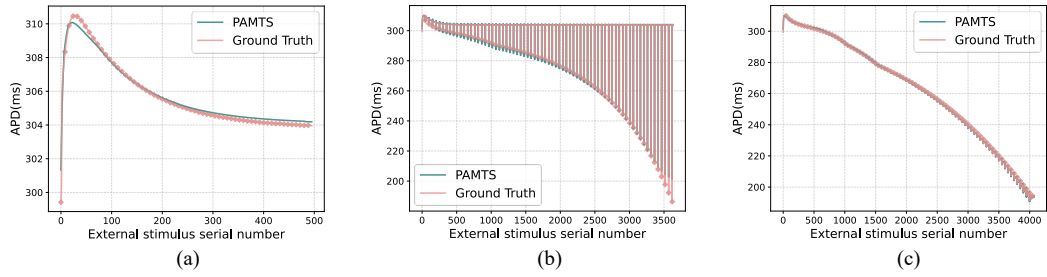


Figure A1 Prediction curves of the APD calculation module under three test pacing protocols. (a) Prediction curves for the uniform protocol corresponding to constant pacing frequency. (b) Prediction curves for the s1-s2 protocol corresponding to abrupt changes in pacing frequency. (c) Prediction curves for the dynamic protocol corresponding to gradual changes in pacing frequency.

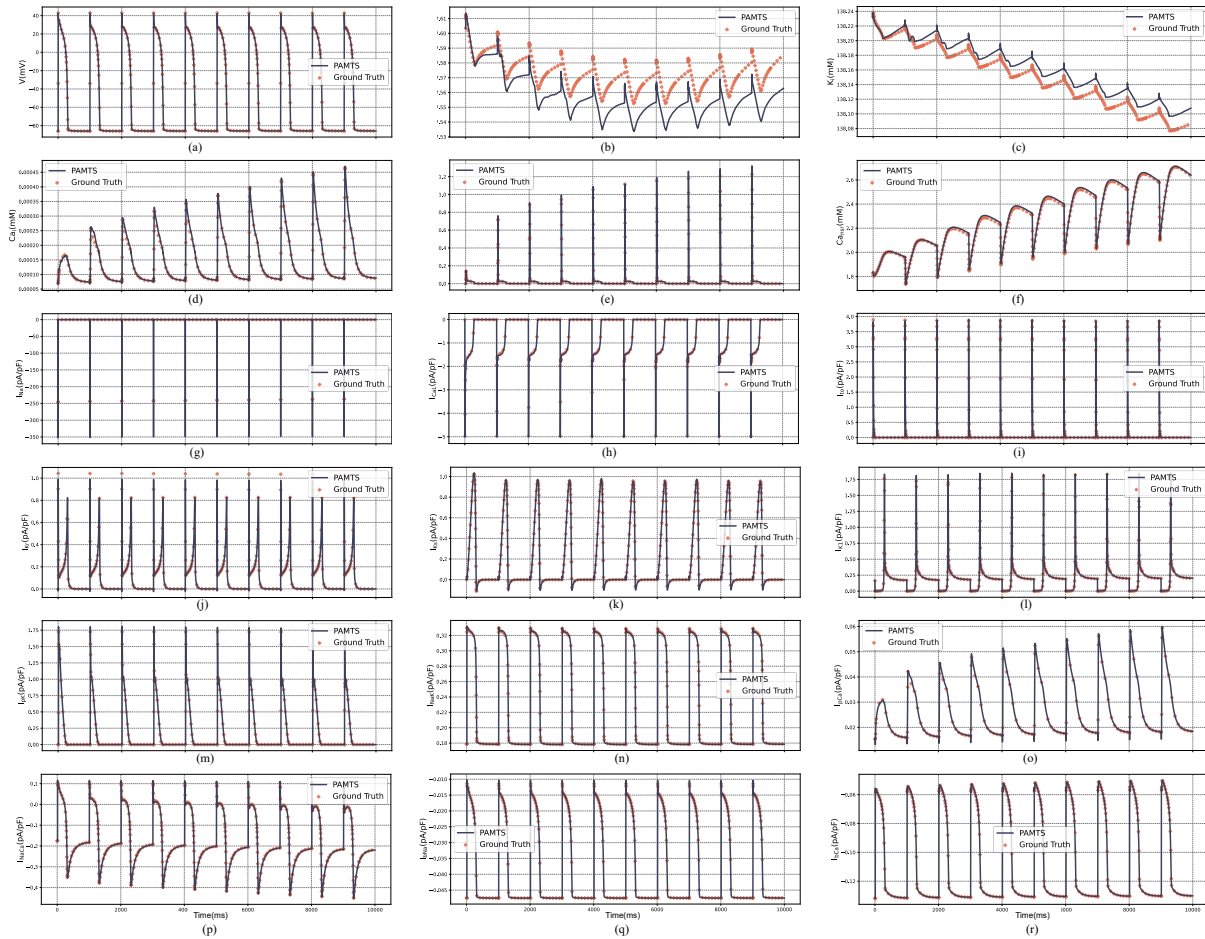


Figure A2 Curves of physiological attributes of endocardial cells during 10 consecutive beats at 1 Hz pacing. (a) action potential. (b) the intracellular sodium (Na_i) concentrations. (c) the intracellular potassium (K_i) concentrations. (d) the free cytoplasmic Ca^{2+} concentration. (e) the free diadic subspace Ca^{2+} concentration. (f) the free sarcoplasmic reticulum Ca^{2+} concentration. (g) fast Na^+ current. (h) L-type Ca^{2+} current. (i) transient outward current. (j) slow delayed rectifier current. (k) rapid delayed rectifier current. (l) inward rectifier K^+ current. (m) Na^+/Ca^{2+} exchanger current. (n) Na^+/K^+ pump current. (o) sarcolemmal Ca^{2+} pump current. (p) plateau K^+ current. (q) background K^+ current. (r) background Ca^{2+} current. Curves indicate predicted results and scatter points indicate Ground Truth.

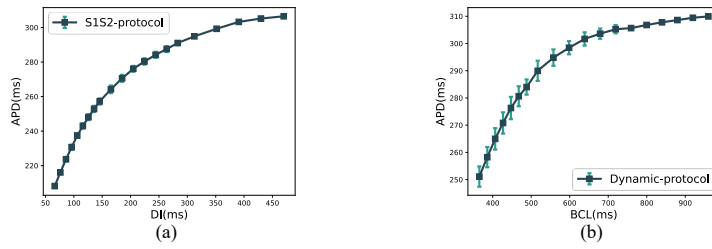


Figure A3 APD restitution curve obtained based on the s1-s2 and dynamic protocols with a basic cycle length of 1000 ms. The error bar length represents the difference between the predicted value and ground truth. (a) APD restitution curve obtained based on the s1-s2 protocol. (b) APD restitution curve obtained based on the dynamic protocol.

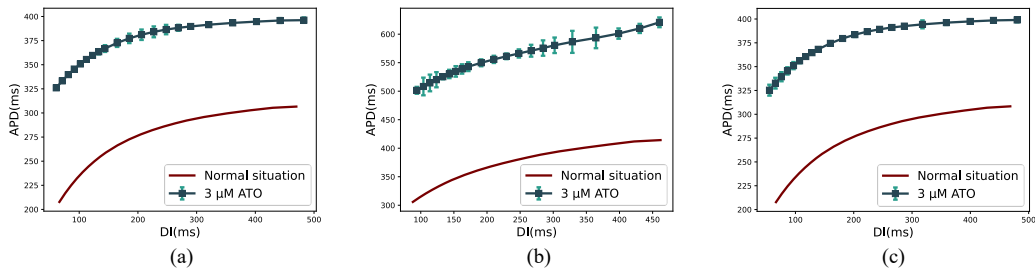


Figure A4 APD restitution curves of ventricular myocytes under the influence of $3 \mu\text{M}$ ATO. (a) Endocardial cell. (b) Myocardial cell. (c) Epicardial cell.

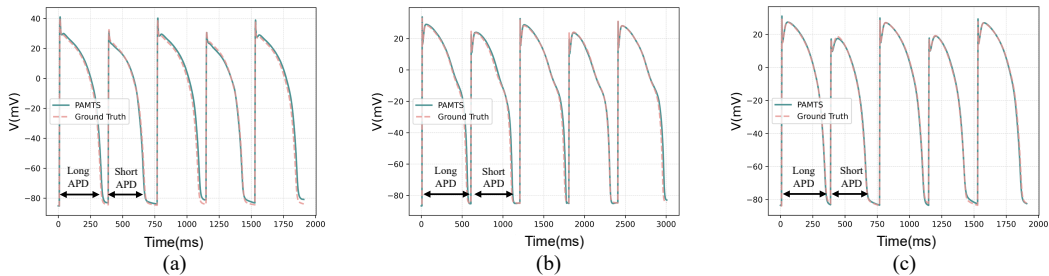


Figure A5 The main phenomenon of alternans is the alternation of the corresponding long and short APD membrane voltages at a fixed pacing frequency. (a) Endocardial cell. (b) Myocardial cell. (c) Epicardial cell.

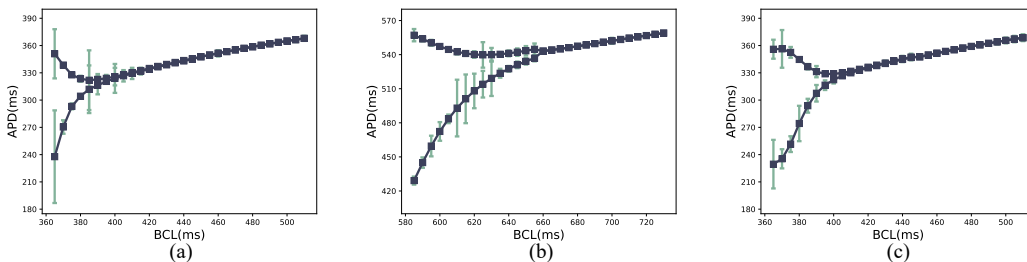


Figure A6 alternans induced by ATO. The bifurcation of the restitution curves indicates the presence of two APDs in a single BCL. (a) Endocardial cell. (b) Myocardial cell. (c) Epicardial cell.