# Learning Paradigm Architectures for Surgical Action Prediction

## Supervised Imitation Learning

Frame Sequence → GPT-2 (Causal)

→ Next Frame + Action Prediction

• *Pure autoregressive modeling*

• *No action conditioning*

## Model-Based RL

State + Action → Transformer

→ Next State + Rewards

• *Action-conditioned simulation*

• *World model + RL policy*

## Model-Free RL

Video Frames → RL Policy

→ Direct Action Selection

• *Direct video interaction*

• *No world model required*

## Shared Training Data: CholecT50 Dataset

Frame Embeddings • Expert Actions • Surgical Phases • Reward Signals

## Unified Evaluation: Surgical Action Prediction

Single-step: state → action_probabilities (identical for all paradigms)

## Performance Results (mAP)

**Supervised IL: 0.737 | Model-Free RL: 0.706 | Model-Based RL: 0.702**

*All paradigms achieve comparable performance!*