Building AI to Play FIFA* Video Game Using Distributed TensorFlow* on Analytics Zoo

Shengsheng Huang, Shan Yu, Jason Dai

Collaborations with Shanghai Jiao Tong University

AGENDA

- Distributed TF on Apache Spark* using Analytics Zoo
- RL Platform for Playing FIFA18
- Playing FIFA18 using Imitation Learning & DRL
- Experimenting with GRF (Google Research Football*)

AGENDA

- **Distributed TF on Apache Spark using Analytics Zoo**
- RL Platform for Playing FIFA18
- Playing FIFA18 using Imitation Learning & DRL
- Experimenting with GRF (Google Research Football)

AI ON BIG DATA

High-Performance
Deep Learning Framework
for Apache Spark

software.intel.com/bigdl

Unified Analytics + AI Platform
Distributed TensorFlow, PyTorch*,
Keras* and BigDL on Apache Spark

https://github.com/intel-analytics/analytics-zoo

ACCELERATING DATA ANALYTICS + AI SOLUTIONS DEPLOYMENT AT SCALE

*Other names and brands may be claimed as the property of others.

intel AI

INTEGRATED BIG DATA ANALYTICS AND AI

SEAMLESS SCALING FROM LAPTOP TO PRODUCTION

- Easily prototype the end-to-end pipeline
- "Zero" code change from laptop to distributed cluster
- Directly access production data without data copy
- Seamlessly deployed on production big data clusters

ANALYTICS ZOO

UNIFIED DATA ANALYTICS + AI PLATFORM

Use case: Recommendation | Anomaly Detection | Text Classification | Text Matching

Model: Image Classification | Object Detection | Seq2Seq | Transformer | BERT

Feature Engineering: image | 3D image | text | time series

Integrated Analytics/AI Pipelines:
- tfpark: Distributed TF on Spark
- Distributed Keras/PyTorch on Spark
- nnframes: Spark Dataframes & ML Pipelines for Deep Learning
- Distributed Model Serving (batch, streaming & online)

Backend/ Library: TensorFlow | Keras | PyTorch | BigDL | NLP Architect | Apache Spark | Apache Flink | Ray | MKLDNN | OpenVINO | Intel® Optane™ DCPMM | DL Boost (VNNI)

https://github.com/intel-analytics/analytics-zoo

intel AI

DISTRIBUTED TENSORFLOW ON SPARK IN ANALYTICS ZOO

```
#pyspark code
train_rdd = spark.hadoopFile(…).map(…)
dataset = TFDataset.from_rdd(train_rdd,…)

#tensorflow code
import tensorflow as tf
slim = tf.contrib.slim
images, labels = dataset.tensors
with slim.arg_scope(lenet.lenet_arg_scope()):
   logits, end_points = lenet.lenet(images, …)
loss = tf.reduce_mean( \
   tf.losses.sparse_softmax_cross_entropy( \
   logits=logits, labels=labels))

#distributed training on Spark
optimizer = TFOptimizer.from_loss(loss, Adam(…))
optimizer.optimize(end_trigger=MaxEpoch(5))
```

Write TensorFlow code inline in PySpark program

MORE INFORMATION ON ANALYTICS ZOO

- Project website
  - https://github.com/intel-analytics/analytics-zoo
- Tutorials
  - CVPR 2018: https://jason-dai.github.io/cvpr2018/
  - AAAI 2019: https://jason-dai.github.io/aaai2019/
- "BigDL: A Distributed Deep Learning Framework for Big Data"
  - *In proceedings of ACM Symposium on Cloud Computing 2019 (SOCC'19)*
- Use cases
  - *Azure, CERN, MasterCard, Office Depot, Tencent, Midea, etc.*
  - https://analytics-zoo.github.io/master/#powered-by/

AGENDA

- Distributed TF on Apache Spark using Analytics Zoo
- **RL Platform for Playing FIFA18**
- Playing FIFA18 using Imitation Learning & DRL
- Experimenting with GRF (Google Research Football)

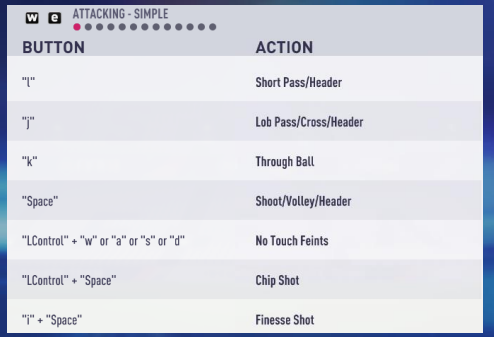
WHY FIFA18?

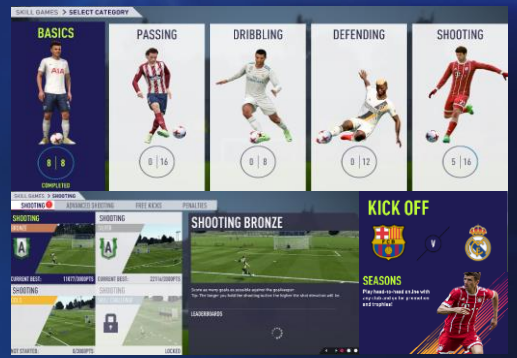
What is FIFA18*?

- **A real-time 3D soccer simulation video game by Electronic Arts***

Why FIFA18?

- **It's fun ☺**
- **It's challenging**
  - **Complex (esp. full-court game) and non-deterministic**
  - **Large action space (16 basic keys w/ combinations)**
- **Many modes available**
  - **Full-court, mini-games, skill games, etc.**





SHOOTING BRONZE: OUR EXPERIMENT ENVIRONMENT

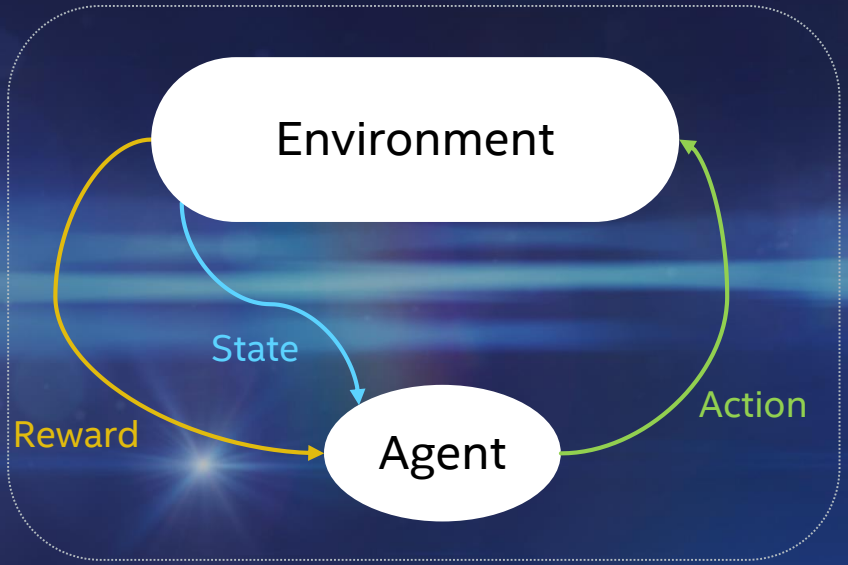
Shooting is one of the mini-games in FIFA18,
Bronze is the easiest level

Game mode
- Player & goalkeeper 1v1
- Goal: get higher score in 44s

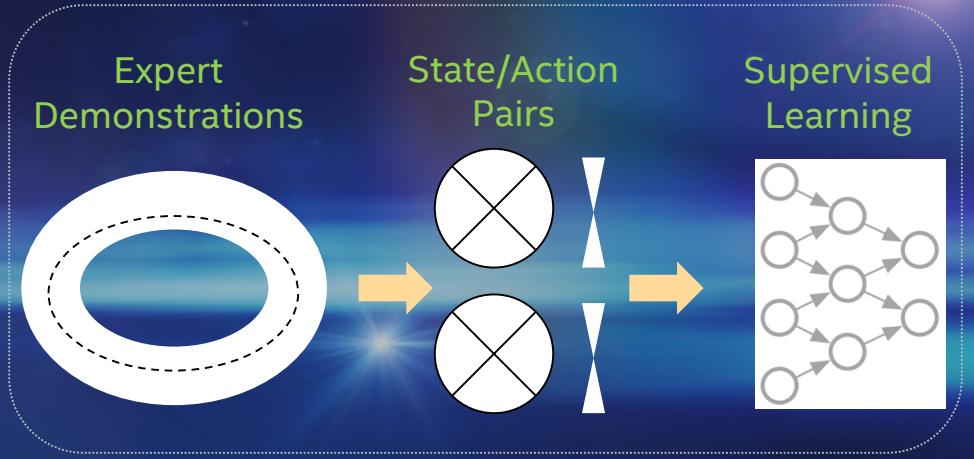
Evaluation
- Single shoot: score ≤ 200 for miss; 200<score<1200 for goal
- Accumulated scores after the game

Keyboard control
- A/S/W/D: left/right/up/down
- Space: shoot

REINFORCEMENT LEARNING



Sequential Decision Making



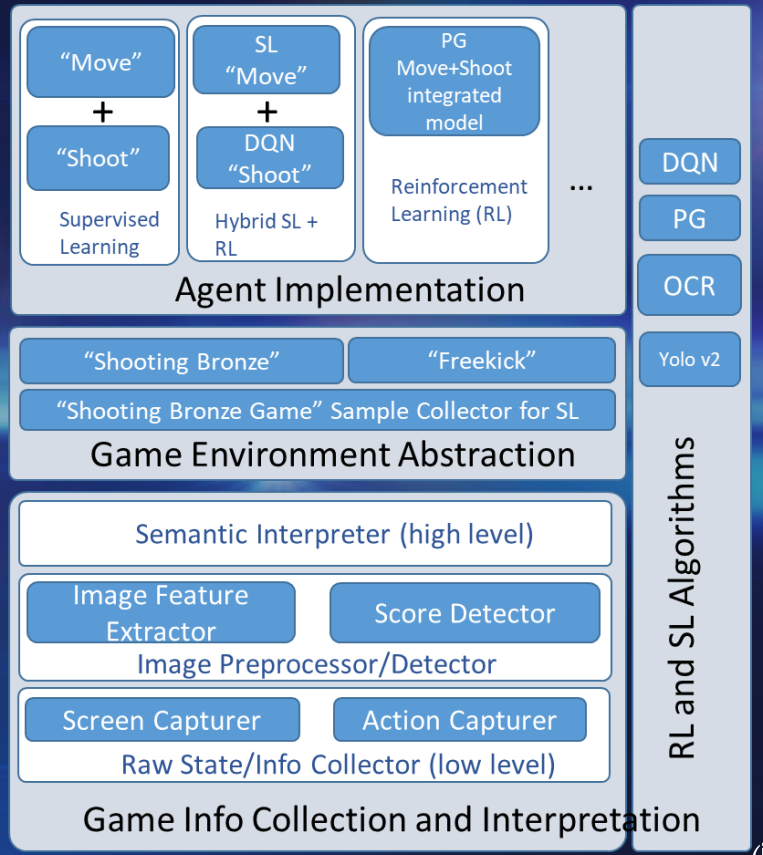
Imitation Learning

RL PLATFORM FOR PLAYING FIFA18

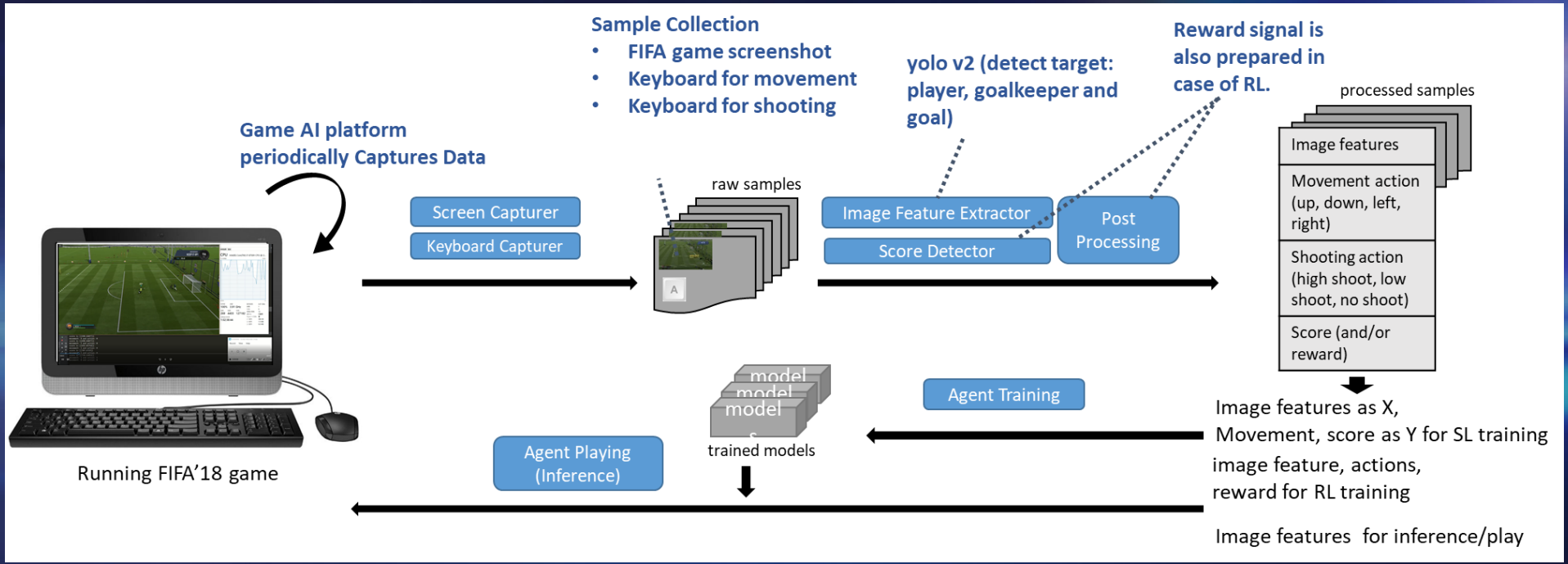
Experiment platform for RL agents and algorithms for FIFA18

Major components

- Game info collection & Interpretation
- Game Environment Abstraction
- Agent Implementation
  - Imitation learning / supervised learning (SL)
  - Reinforcement learning (RL)
  - Hybrid (SL+RL)



END-TO-END WORKFLOW



ANALYTICS ZOO

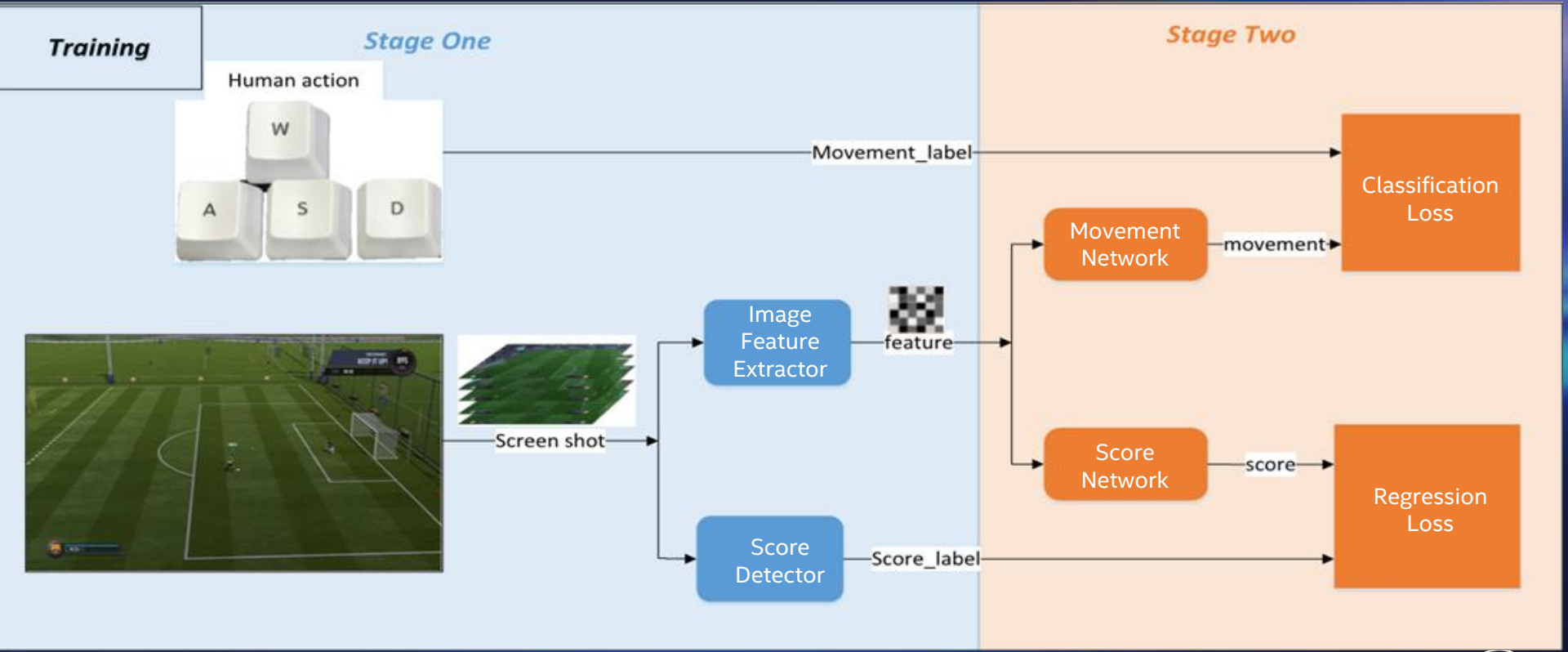
tfpark: Distributed TensorFlow on Spark

intel AI

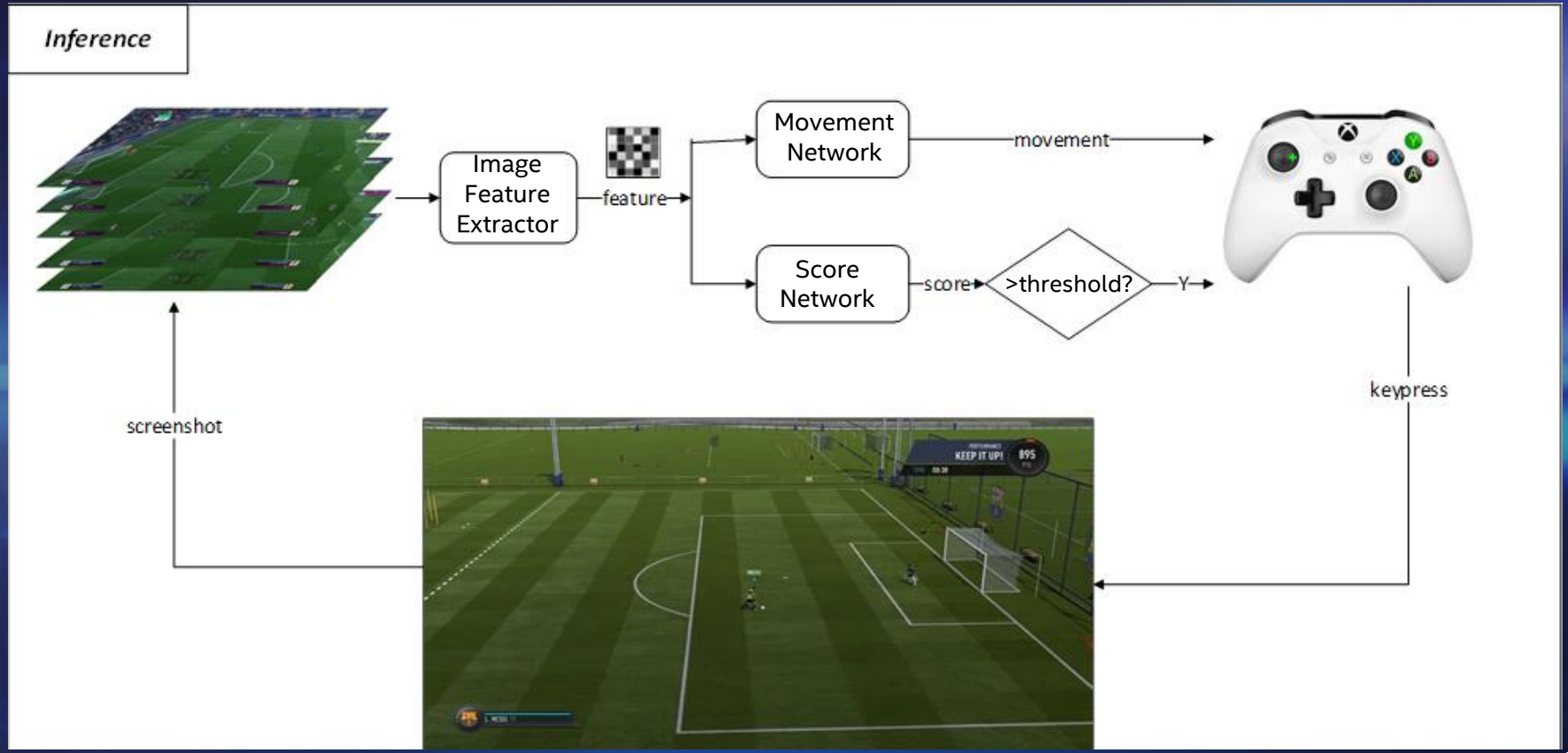
AGENDA

- Distributed TF on Apache Spark using Analytics Zoo
- RL Platform for Playing FIFA18
- **Playing FIFA18 using Imitation Learning & DRL**
- Experimenting with GRF (Google Research Football)

TRAINING THE AGENT USING IMITATION LEARNING



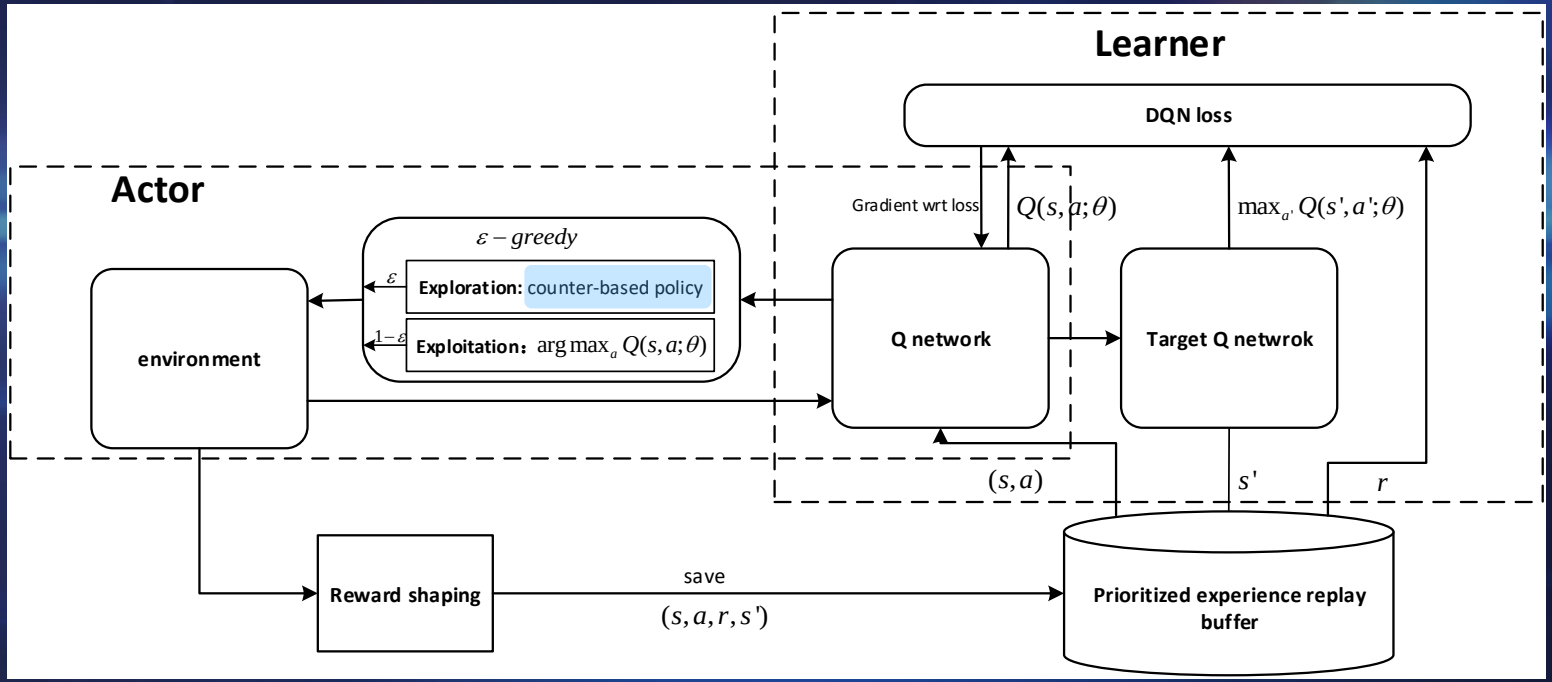
GAME PLAYING (INFERENCE) FOR IMITATION LEARNING



HYBRID APPROACH FOR TRAINING AGENT

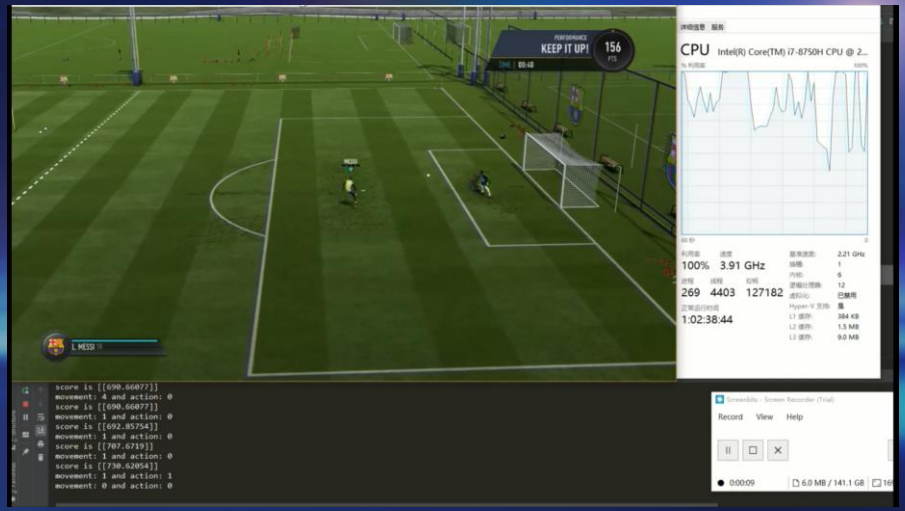
Movement network: trained with Imitation Learning

Shoot network: Double DQN



DEMO

https://drive.google.com/file/d/13dBsGOiGbCYOS5TgVAI95Qd-YszAHTW6/view



https://drive.google.com/file/d/1JVZjlDSyX8YtUy6qOuGRD_VN4RSZw0U8/view

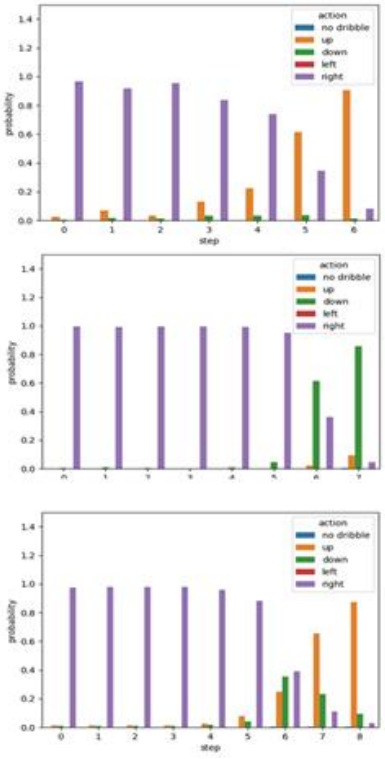
Human (demonstrator)

Imitation Learning (better score than demonstrator)

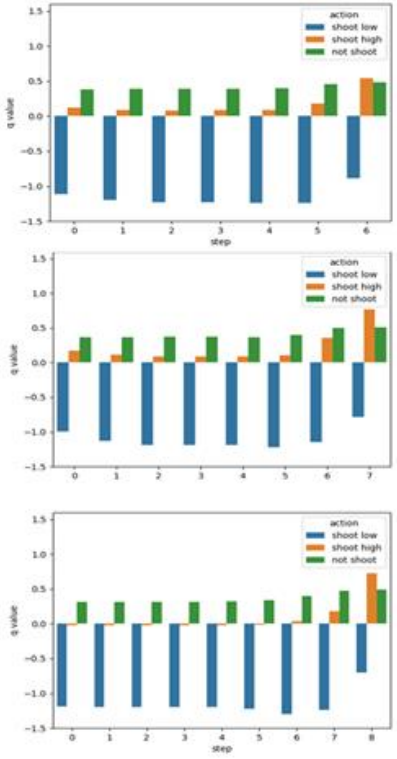
TYPICAL TRAJECTORY ANALYSIS (HYBRID)

Typical Trajectories

Movement Policy (SL)



Shoot Q-Value (RL)



RESULTS

		Score	Goal Ratio	Convergence speed
Human	beginner	5846.69	50%	-
	master	10112.78	92%	-
	demonstrator	7284.98	84.96%	-
Agent	Imitation Learning	10345.18	92.54%	-
	RL (Policy Gradient)	5606.31	40.25%	1069.5 epochs
	Hybrid	10514.43	95.59%	749.6 epochs

For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.

AGENDA

- Distributed TF on Apache Spark using Analytics Zoo
- RL Platform for Playing FIFA 2018
- Playing FIFA using Imitation Learning & DRL
- Experimenting with GRF (Google Research Football)

GOOGLE RESEARCH FOOTBALL (GRF)

An open source RL environment for playing soccer from Google Brain

- https://github.com/google-research/football

A great RL environment for playing soccer

- More state and reward info & controls
- Customizable scenarios, players, rewards and observations, etc.
- More useful features such as accelerated speed, self-play, multi-agent, etc.
- Easy to dump traces and replay

Transfer between FIFA18 and GRF?

Google Research Football: A Novel Reinforcement Learning Environment (https://arxiv.org/abs/1907.11180)

EARLY EXPERIMENTS ON GRF

https://drive.google.com/file/d/1bNO5rpUhCeCZY9zPGgVCzgUlqH9QF39n/view

Trained using PPO in OpenAI* baseline

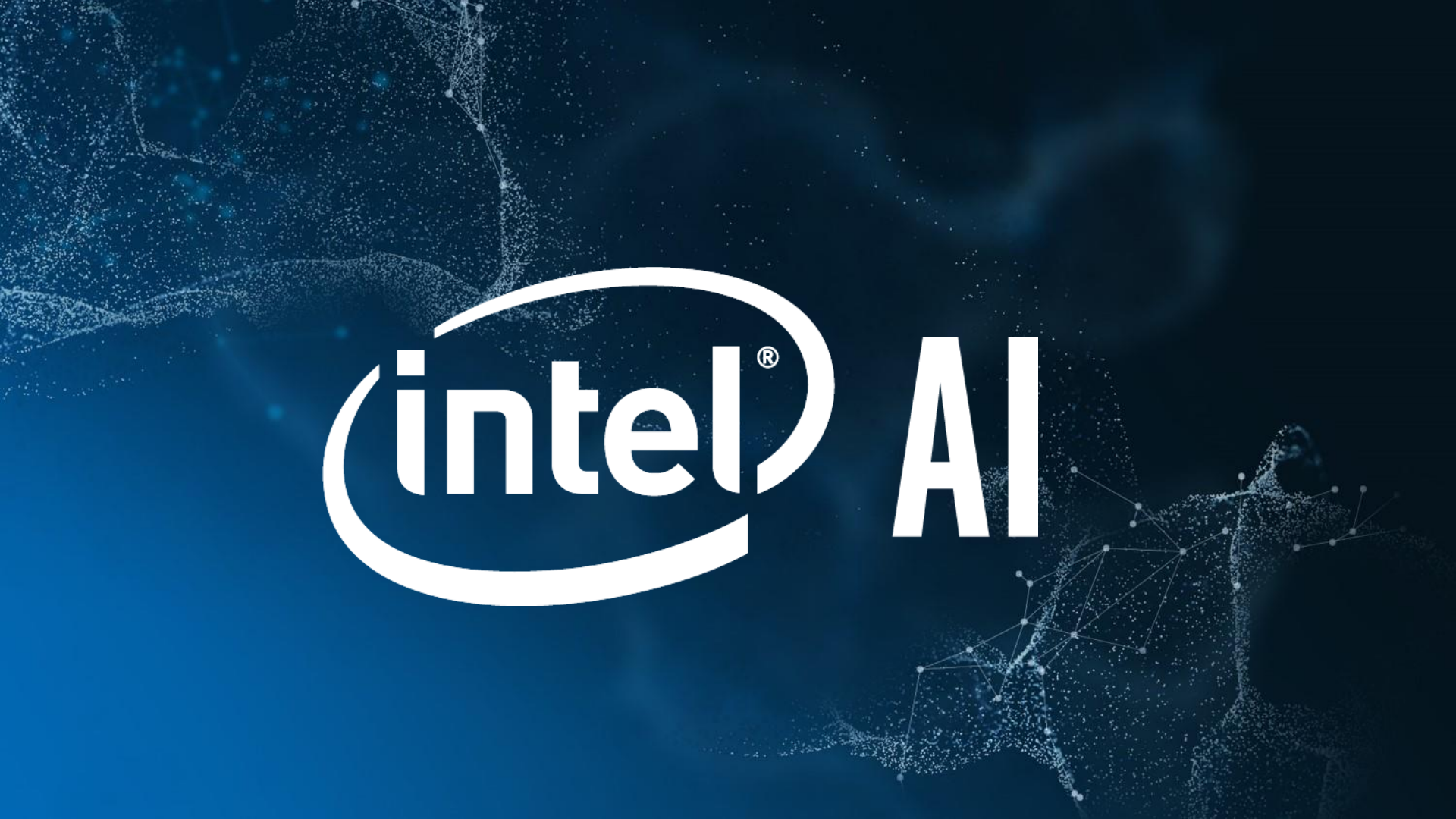
FUTURE WORK

Ray* support in Analytics Zoo
- E.g., *RayOnSpark*

Support for *Google Research Football*
- *E.g., transfer between GRF and FIFA?*

Additional algorithms/models and scenarios
- E.g., *full-court* game

https://medium.com/riselab/rayonspark-running-emerging-ai-applications-on-big-data-clusters-with-ray-and-analytics-zoo-923e0136ed6a


intel®
AI

LEGAL NOTICES AND DISCLAIMERS

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations, and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more complete information visit intel.com/performance.

Intel does not control or audit the design or implementation of third-party benchmark data or websites referenced in this document. Intel encourages all of its customers to visit the referenced websites or others where similar performance benchmark data are reported and confirm whether the referenced benchmark data are accurate and reflect performance of systems available for purchase.

Optimization notice: Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software, or service activation. Performance varies depending on system configuration. No computer system can be absolutely secure. Check with your system manufacturer or retailer or learn more at intel.com/benchmarks.

intel AI