Half Field Offense
Technical Manual

Matthew Hausknecht

April 8, 2015

Contents

1 Overview

This document describes the state and action spaces of the HFO domain.

2 State Space

The state features used by HFO are designed with the mindset of providing an overcomplete, basic, egocentric viewpoint. The features are basic in the sense that they provide distances and angles to relevant points of interest, but do not include higher level perceptions such as the largest angle between a goal post and goalkeeper.

All features are encoded as floating point values normalized to the range of [-1,1]. Different types of features are discussed next.

2.1 Boolean Features

Boolean features assume either the minimum feature value of -1 or the maximum feature value of 1.

2.2 Valid Features

Since feature information is attained from the Agent's world-model, it is possible that, the world model's information may be stale or incorrect. *Valid features* are boolean features indicating consistency of world model predictions. For example, if the world model's estimate of the agent's position is known to be flawed, the *valid feature* for self position would assume the minimum value of -1. Otherwise it will assume the maximum value of 1.

The features associated with a valid feature are given the value of zero if an inconsistency is detected. For example, if the world model detects that the agent's velocity is invalid, the feature that encodes the magnitude of self velocity will be set to zero.

2.3 Angular Features

Angular features (e.g. the angle to the ball), are encoded as two floating point numbers – the $sin(\theta)$ and $cos(\theta)$ where θ is the original angle.

This encoding allows the angle to vary smoothly for all possible angular values. Other encodings such as radians or degrees have a discontinuity that when normalized, could cause the feature value to flip between the maximum and minimum value in response to small changes in θ.

2.4 Distance Features

Distance features encode the distance to objects of interest. Unless otherwise indicated, they are normalized against the maximum possible distance in the HFO playfield (defined as $\sqrt{l^2 + w^2}$ where l, w are the length and width of the HFO playfield). A distance of zero will be encoded with the minimum feature value of -1 while a maximum distance will be encoded with 1.

2.5 Landmark Features

Landmark features encode the relative angle and distance to a landmark of interest. Each landmark feature consists of three floating point values, two to encode the angle to the landmark and one to encode the distance. Note that if the agent's self position is invalid, then the landmark feature values are zeroed.

2.6 Player Features

Player features are used to encode the relationship of the agent to another player or opponent. Each player feature is encoded as 1) a landmark feature of that player's location 2) the global angle of that player's body 3) the magnitude of the player's velocity and 4) the global angle of the player's velocity. Eight floating point numbers are used to encode each player feature.

2.7 Other Features

Some features, such as the agent's stamina, do not fall into any of the above categories. These features are referred to as *other features*.

3 State Feature List

Basic Features are always present and independent of the number of teammates or opponents. The 32 basic features are encoded using 58 floating point values (*angular features* require two floats, *landmark features* require 3). Additionally a variable number of *player features* are then added. This number depends on the number of teammates and opponents in the HFO game, but 8 floating point values are required for each player feature. Thus, the total number of features is $58 + 8 * \text{num\_teammates} + 8 * \text{num\_opponents}$.

- **Self_Pos_Valid** [Valid] Indicates if self position is valid.
- **Self_Vel_Valid** [Valid] Indicates if the agent's velocity is valid.
- **Self_Vel_Ang** [Angle] Angle of agent's velocity.
- **Self_Vel_Mag** [Other] Magnitude of agent's velocity. Normalized against the maximum observed self speed, 0.46.
- **Self_Ang** [Angle] Agent's Global Body Angle.
- **Stamina** [Other] Agent's Stamina: The amount of remaining stamina the agent has. Normalized against the maximum observed agent stamina of 8000.
- **Frozen** [Boolean] Indicates if the agent is Frozen. Frozen status can happen when being tackled by another player.
- **Colliding_with_ball** [Boolean] Indicates if the agent is colliding with the ball.
- **Colliding_with_player** [Boolean] Indicates if the agent is colliding with another player.
- **Colliding_with_post** [Boolean] Indicates if the agent is colliding with a goal post.
- **Kickable** [Boolean] Indicates if the agent is able to kick the ball.
- **Goal Center** [Landmark] Center point between the goal posts.
- **Goal Post Top** [Landmark] Top goal post.
- **Goal Post Bot** [Landmark] Bottom goal post.
- **Penalty Box Center** [Landmark] Center of the penalty box line.
- **Penalty Box Top** [Landmark] Top corner of the penalty box.
- **Penalty Box Bot** [Landmark] Bottom corner of the penalty box.
- **Center Field** [Landmark] The left middle point of the HFO play area. True center of the full-field.

- **Corner Top Left** [Landmark] Top left corner HFO Playfield.
- **Corner Top Right** [Landmark] Top right corner HFO Playfield.
- **Corner Bot Right** [Landmark] Bot right corner HFO Playfield.
- **Corner Bot Left** [Landmark] Bot left corner HFO Playfield.
- **OOB Left Dist** [Distance] Distance to the nearest point of the left side of the HFO playable area. E.g. distance remaining before the agent goes out of bounds in left field.
- **OOB Right Dist** [Distance] Distance remaining before the agent goes out of bounds in right field.
- **OOB Top Dist** [Distance] Distance remaining before the agent goes out of bounds in top field.
- **OOB Bot Dist** [Distance] Distance remaining before the agent goes out of bounds in bottom field.
- **Ball Pos Valid** [Valid] Indicates if the ball position estimate is valid.
- **Ball Angle** [Angle] Angle to the ball from the agent's perspective.
- **Ball Dist** [Distance] Distance to the ball.
- **Ball Vel Valid** [Valid] Indicates if the ball velocity estimate is valid.
- **Ball Vel Mag** [Other] Global magnitude of the ball velocity. Normalized against the observed maximum ball velocity, 3.0.
- **Ball Vel Ang** [Angle] Global angle of ball velocity.
- **Teammate Features** [Player] One teammate feature for each teammate active in HFO, sorted by proximity to the agent.
- **Opponent Features** [Player] One opponent feature for each opponent present, sorted by proximity to the player.

4 Action Space

The action space of the HFO domain is primitive: basic parameterized actions are provided for locomotion and kicking. Control of the agent's head and gaze is not provided. The primitive actions are as follows:

- **Dash**(power, degrees): Moves the agent with power [-100, 100] where negative values move backwards. The relative direction of movement is given in degrees and varies between [-180,180] with 0 degrees being a forward dash and 90 degrees dashing to the agent's right side. Note, dashing does not turn the agent.
- **Turn**(degrees): Turns the agent in the specified direction. Valid values range between [-180, 180] degrees where 90 degrees turns the agent to directly to its right side.
- **Tackle**(degrees): Contest the ball. Direction varies between [-180, 180]. TODO: Better description.
- **Kick**(power, degrees): Kick the ball with power [0, 100] in relative direction [-180, 180]. Has no effect if the agent does not possess the ball.
- **Quit**: Indicates to the agent server that you wish to terminate the HFO environment.