# Abstract

# Introduction

# Background

## RTS Games

## Strategy Dimensionality

In order to identify opponent strategies it is first necessary to produce a representation of strategy that is robust to the various nuances among the many possible tactics. In StarCraft every unit, building, and research upgrade has a fixed set of pre-requisites that must exist before the item can be produced which when combined produce a single “tech tree” for the race. Spawning from this representation is the notion of “build order”, or a unique set of ordered productions designed to optimize the efficiency of a particular strategy. This build order can be represented as a subtree consisting of only the nodes in the tech tree that are required to achieve that series of productions. Every strategy in StarCraft can be represented by a build order, and while there is nuance to the exact implementation of that build order, such as building location placement or map exploration, the order itself does not change.

Strategies in IRE are represented as build orders geolocated in a 3-dimensional “strategy space”. This strategy space consists of virtual axes that represent the intensities of all possible strategies along common metrics, where each axis is normalized from -1 to 1. The first axis measures a strategy’s focus on ground units versus anti-ground units. The second axis measures a strategy’s focus on air units versus anti-air units, and the third axis measure’s a strategy’s overall aggressiveness versus defensiveness. The closer to zero a point is along any given axis, the more “balanced” that strategy is in producing units that can achieve, or fails to achieve, both extremes. For example, a strategy that emphasizes aggressively building ground units that cannot attack air units to attack the enemy without concern for base defense would measure as a 1 on the ground axis, a 0 on the air axis, and a 1 on the aggression axis. Conversely, a strategy that involves building heavy base defenses to produce a late-game aerial armada would measure as a -1 on the ground axis, a 1 on the air axis, and a -1 on the aggression axis.

These axes were selected because all units in StarCraft are either air or ground units, and each can either attack ground units, air units, or both. In addition, successful strategies in StarCraft either emphasize building attacking units as quickly as possible, or defending against opponent “rushes” to produce more powerful units, but ultimately a victory can only be achieved through enemy defeat. Although these particular axes were chosen due to their relevance to the most common build orders, any arbitrary axis could be selected and added to the code without consequence to IRE.

Strategies, represented as build order subtrees, are given a ranking along each axis that represent that particular strategy’s “fingerprint”. For testing, the 18 most common build orders were codified in this manner and scored [TABLE X Y Z].

<TABLE X>

<TABLE Y>

<TABLE Z>

When a strategy is loaded into strategy space, each node in the subtree is given a 3-dimensional point representing its intensity along those axes. Strategies are normalized to their unique depth, where the lowermost nodes have intensities matching the strategy’s overall values and all other nodes scale evenly between those values and zero. So a node halfway down a strategy with an aggressiveness of 1 would have an aggressiveness value of 0.5.

## Probability Density Functions

# Converting Observations into Predictions

The combined set of all strategies in a single strategy space create a virtual realm where the enemy’s actual tactics must be located. The goal of IRE is to use observed enemy units to attempt to “geolocate” the enemy’s tactics within this space. Initial observations will begin to bias NOVA’s decisions in what units to produce towards those that are more effective against certain strategies. As more and more enemy units are observed, likely strategy “locations” will begin to layer on top of each other, creating a multiplicative effect until the single most likely strategy is observed. Because producing units takes time and resources, the probability that an enemy attempting an anti-air strategy as they produce units incapable of achieving these strategies approaches zero as the number of observed units increases.

# Experimental Evaluation

# Related work

# Conclusions

# Future Work

# References