

Lecture Note on the Husky Project

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1 Introduction

The husky project (<https://github.com/ancient-software/husky>) is currently a project in computer vision, which starts five years ago even before my PhD.

(Pdf of lecture note: <https://github.com/ancient-software/husky/blob/main/sparks/impress/lecture1.pdf>)

(Latex Source of lecture note: <https://github.com/ancient-software/husky/blob/main/sparks/impress/lecture1.tex>)

Warning: this is work in progress. It shall take a long time to complete this note.

1.1 Composition

It comprises mainly of two parts:

- (1) a new machine learning framework with new algorithms and ways of feature constructions that are geometrically more appropriate for shape analysis;

Remark. *todo: explain what is geometrically appropriate*

- (2) a new programming language that is critical for interactively implementing and improving efficient and fully interpretable models.

Remark. *PL is generalizable to other domains, like NLP, Theorem Proving, Robotics, RL, Computer Graphics, etc. I'm in the way of overhauling the type system to introduce Monad for NLP and Robotics and RL and Prop for theorem proving.*

As a result, this PL is an extremely ambitious project that must have all good things from languages in different domains, C++/Rust/Zig from system level programming

Remark. *todo: explain why this is difficult for previous experts in the field.*

1.2 Difference

Traditional Computer Vision. Handcrafted feature descriptors such as SIFT and SURF are fed to traditional machine learning classification algorithms such as Support Vector Machines and k-Nearest Neighbours to solve the aforementioned CV problems.

Computation: matrix (mostly)

Biggest problem: doesn't work well for large datasets.

Deep Learning. End to end training.

Computation: matrix

Biggest problem: doesn't explain well, totally not scientific.

Husky. Interactively construct features that is interpretable and efficient, first purely by hand then automate more and more in the process. Feature is no longer just a map from input to a vector space, it's a map from input to a type, which encodes information in an domain specific, interpretable and efficient way.

For image classification, the training process is replaced by the following iterative developing process (with labeling being part of it)

- Replace the goal of finding an all-powerful classifier by finding for each class a one-vs-all classifier.

Remark. *When the number of classes is really large, we will use LSH(locally sensitive hashing)-like schemes. But for imagenet, this is not necessary.*

- For each class, try to represent the one-vs-all classifier by a cascade, i.e. a sequence of partial classifiers together with a one-vs-all classifier in the end.

todo: explain partial classifier

- Partial classifiers are first constructed by hand interactively. Constantly interact with the debugger.

This process maps to a drastically different set of requirements on development tools:

- Require the ability to easily write system level programming because we are not using matrices

Remark. *This rules out python.*

- Incrementally compute the features in a functional way, i.e. instant response even for imagenet

Remark. *This rules out every existing language, especially those requiring long compilation time like C++/Rust/Zig. But python and julia are kind of okay because they can run in a notebook environment. The only problem is that notebook is procedural, not functional, can't scale every well.*

- One-click visualization of one or more features (possibly restricted to a branch or a datapoint)

Remark. *This rules out every existing language.*

- Higher order functions for automation: one expr for constructing and training a model

Remark. *This rules out every existing language.*

- Automatic memory

Remark. *This rules out every existing language except Rust.*

- Automatic lazy value cache management across domains

Remark. *This rules out every existing language. Haskell has features that sounds similar, but isn't good enough.*

- Rigorous type system to avoid distracting programmer from the task at hand

Remark. *This rules out python.*

So that's why I feel it necessary to develop a new language.

1.3 Future

The future is going to be like:

- in two years, imagenet is done in husky by myself, totally interpretable and as accurate and 100 times faster for inference; the development only requires a moderate computer and it doesn't need GPU for training and inference.

Roughly speaking, it's going to be like:

- 4 months recognise husky
- 4 months recognise 9 more classes
- 4 months recognise 90 more with automation
- 4 months recognise 900 more with much better automation
- 8 months for improvement on all fronts
- gains popularity because husky doesn't require GPU and is a new programming language that is much more easier to make right than python, and can publish papers because people are convinced.
- husky applies to Computer Graphics(GAN, etc.), RL, Robotics
- I will raise funding for NLP and theorem proving, in 5 to 30 years will replace large language models (transformers, etc)

1.4 Now

The current state of the project is

- theoretical stuffs are clear (nothing changes significantly from two years ago); mathematically I'm fully convinced that things will work. However, to be convincing for other people with less mathematical maturity, this is probably not enough. But it doesn't really matter because I'm going to be the one who can make essential contribution to the project due to the complexity of things.
- a minimal (barely) working version of language is there, for which I wrote many code in the last two years.
 - first year work C++
 - second year Rust
- have only spent very limited time in actually making it work
 - using the C++ version a model for mnist which is 97% accuracy for half of the data

- Mnist using the latest version in progress. Not in a hurry, because people aren't convinced by Mnist no matter how good the result is. Will do it when I have the mood.
- Imagenet in progress,

Remark. *todo: explain what percentage means*

1.5 Past

It initially is very different, the path is

- deep learning theory
- algorithm + machine learning
- geometric algorithm
- programming language

2 Inference Process for Image Classification

2.1 Mnist

2.2 Imagenet(tentative)

3 Theoretical Framework: Nontrivial Machine Learning

Example (Linear Classification).