Hoogλe

Fast Type Searching

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Hoogle Synopsis

> Hoogle is a Haskell API search engine, which allows you to search many standard Haskell libraries by either function name, or by approximate type signature.

Or, Google for Haskell

Hoogle Background

- Over 4 years old
- 4 major versions (each a complete rewrite)
  - Version 1 in Javascript, 2-4 in Haskell
- Over half a million queries with Hoogle 3

- I am current working full-time on Hoogle thanks to Google Summer of Code and haskell.org (2 weeks left!)

Exact Searching

- You ask, Hoogle responds:
  - map — Prelude.map
  - Map — module Data.Map
  - $(a \to b) \to [a] \to [b]$ — Prelude.map
  - $\text{Ord } a \Rightarrow [a] \to [a]$ — Data.List.sort

- Exact searching is easy!

Inexact Text Searching

- Exact text matching is really easy (Trie)
- Substring matching is really easy (Trie with different entries)
- Can use Levenshtein/edit distance (harder to implement)

- Hoogle (1-4) all use substring matching
  - Hoogle 4 uses a Trie, 1-3 use linear search

Inexact Type Searching

- Most study has been on type isomorphisms (useless for searching)
- Want to “read the users mind”
- The game: I put up some type signatures, you guess the best answer

Human Search Engine

- $a \rightarrow [(a,b)] \rightarrow b$
- $Int \rightarrow Int \rightarrow Int$
- $[a] \rightarrow [b]$
- $[Int] \rightarrow String$
- $[a] \rightarrow (a \rightarrow b) \rightarrow [b]$
- $a \rightarrow Maybe$
- $a \rightarrow Just\ a$
- $float \rightarrow float$

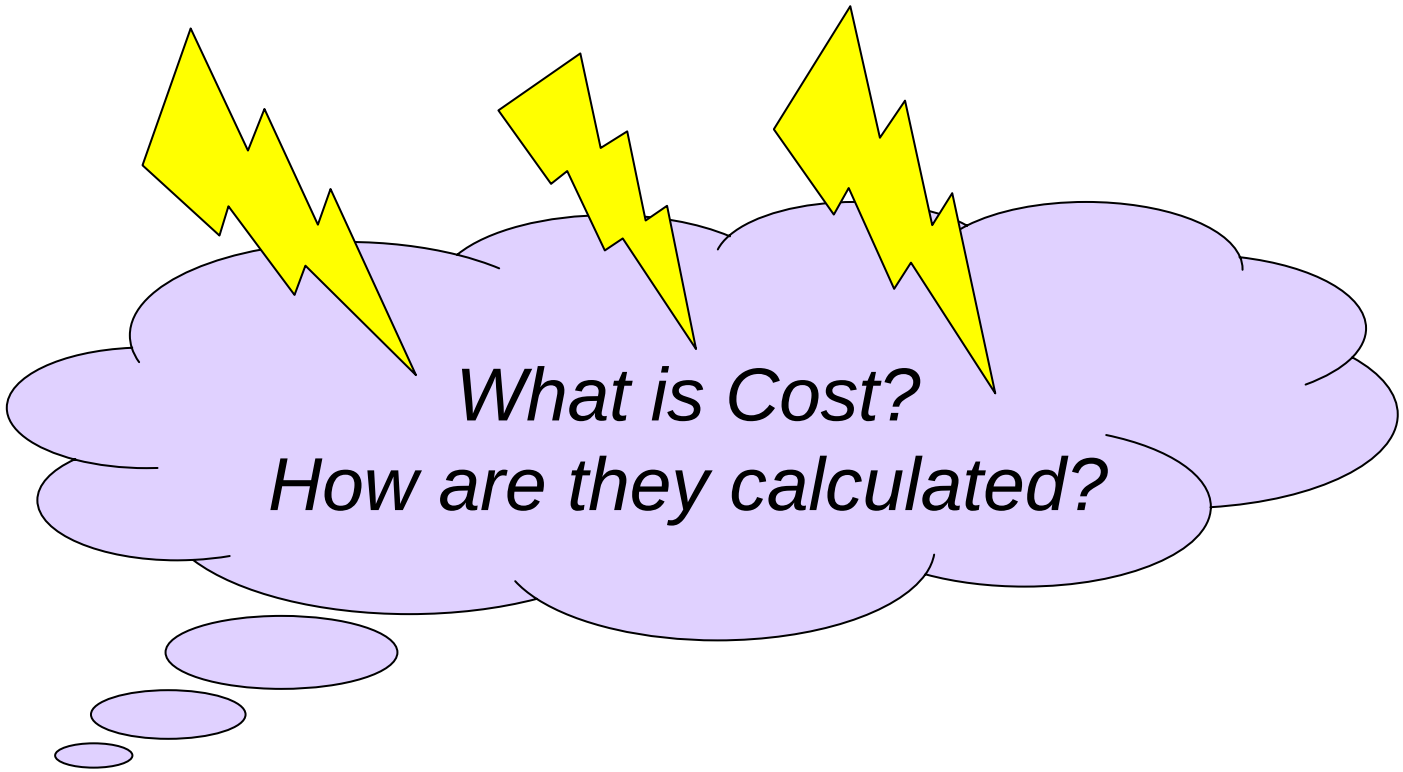
Ranking

- Hoogle ranks results using a multiset of costs (about 14 in Hoogle 4)
  - You missed an argument (badarg)
  - You missed an instance (badinst)

- match :: Query $\rightarrow$ Result $\rightarrow$ Maybe [Cost]
  - Do not need to worry about ordering marks

Brainstorm

- match :: Query → Result → Maybe [Cost]



Ideas

- Alpha equality (Hoogle 1)
- Isomorphism (Rittri, Runciman – 1980's)
- Textual type searching (Hayoo!)
- Unification (Hoogle 2)
- Edit distance (Hoogle 3)
- Full edit distance (Hoogle 3.5)
- Structural edit distance (Hoogle 4)

Alpha equality

- Take a type signature, and “normalise” it
- Rename variables to be sequential
- The do an exact text match

- $k \to v \to \text{Map } k\ v$
- $a \to b \to \text{Map } a\ b$

Isomorphism

- Only match types which are isomorphic
  - Long before instances/type aliases
- Ismorphism is about equal structure
  - $a \to b \to c \equiv (a, b) \to c$

- uncurry :: $(a \to b \to c) \to (a, b) \to c$
- :: $(a \to b \to c) \to a \to b \to c$

Textual Type Searching

- Alpha normalise + strength reduced alpha normalisation

- $k \to v \to Map\ k\ v$
- $a \to b \to Map\ a\ b$ & $a \to b \to c\ a\ b$

- Plus substring searching

Unification

- Unify against each result, like a compiler
- The lookup problem:
  - $a \to [(a,b)] \to b \neq a \to [(a,b)] \to \text{Maybe } b$
- Works OK, but not great, in practice
  - Gives more general answers, but not less general
- People are too fuzzy in their requests

Edit Distance

- What changes do I need to make to equalise these types
- Each change has a cost
  - $a \to [(a,b)] \to b$
  - $a \to [(a,b)] \to \text{Maybe } b$
  - $\text{Eq } a \Rightarrow a \to [(a,b)] \to \text{Maybe } b$
- The same idea in Hoogle 3.5 and 4, but different implementations

Hoogle 3 Edit Distance

- database :: [Type], length database ≡ *n*
- match :: Type → Maybe [Cost]

- [t | t ← database, Just c ← [match t],
  order by c]
  - *O(n)* to search all items
  - *O(n)* to find the first result

Hoogle 3.5/4 Costs

- Alias following (String $\leftrightarrow$ [Char])
- Instances (Ord a $\Rightarrow$ a $\leftrightarrow$ a)
- Boxing (a $\leftrightarrow$ m a , a $\leftrightarrow$ [a])
- Free variable duplication ((a,b) $\leftrightarrow$ (a,a))
- Restriction ([a] $\leftrightarrow$ m a , Bool $\leftrightarrow$ a)
- Argument deletion (a $\rightarrow$ b $\leftrightarrow$ b)

Per Argument Searching

- The idea: Search for each argument separately, combine the results
  - Some costs are applied in combination

- i.e. Search a $\rightarrow$ b $\rightarrow$ c
- combine $ search arguments a `merge`
  search arguments b `merge`
  search results c

Combine/Search

- search returns results for a particular type within a set of types in order of rank

- combine takes a list of results for arguments, and combines them into results matching an entire signature, removes duplicates, checks each argument is present etc.

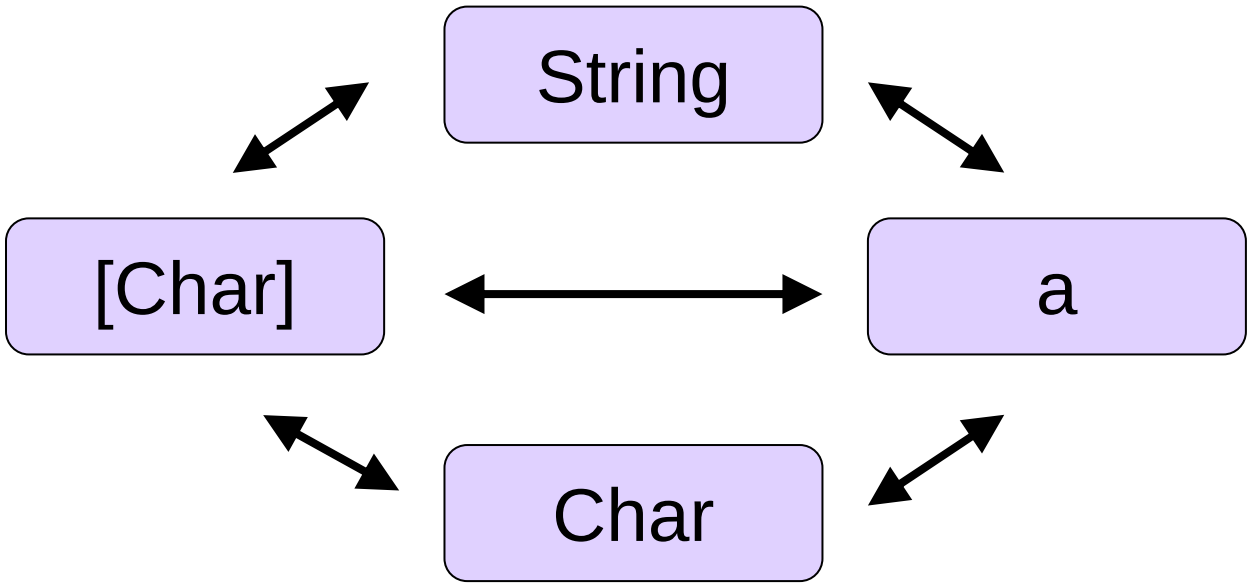
Combine Notes

- Combine is fiddly
- Needs to apply costs such as instances, variable renaming, argument deletion
- As soon as it knows no result will rank lower, it returns a result

- Fast to search for the best matches

Hoogle 3.5 Search

- Have type graphs, annotated with costs
  - Dijkstra's graph search algorithm



The Problem

- Finds the first result very quick
- Graphs may be really big
- But a particular search may match many results in many ways
  - Finding all results can take some time
  - ~5 secs with 5000 functions

- Need to be more restrictive with matching!

Hoogle 4 structure matching

- We can decompose any type into a structure and a list of terms
- Either (Maybe a) (b,c)
- ? (? ?) (? ? ?) + Either Maybe a (,) b c

- Searching for a type involves finding an exact structure match and then a binding to the list of terms

Hoogle 4 additional costs

- Structure matching ignores a number of costs
  - Aliases – fully expand all aliases initially, combine has a heuristic to pay for them
  - Box/Unbox – allow one box/unbox at the top level, just perform 3 structure searches
- The base libraries have at most 22 different term sequences for a structure

Hoogle 4 results

- Fast to find the first result, fast to find all results, ~0.5sec on the base libraries
- Fast enough to develop and debug using Hugs on all the base libraries
  - Very helpful to me!
- Hoogle 4 demo, network connection permitting…

Ranking Costs

- Given a multiset of costs, need to order the results
- Solution: Assign each cost an integer, sum the costs, compare these numbers
- Initial attempt: Make up numbers manually
  - Did not scale at all, hard to get right, like solving a large constraint problem in your head

Hoogle 3/4 Ranking

- Hoogle has a ranking file, a list of searches with the desired order of results
- When someone complains, I add their complaint to this list

- Generates a set of constraints, then solves
  - Hoogle 3 used ECLiPSe constraint solver
  - Hoogle 4 uses a custom finite domain search

Hoogle Statistics

- 560,000 searches with Hoogle 3
- About 1 in 6 searches are type searches
  - I never do type search with Hoogle!
  - Type searches decreasing with time
- Becoming an essential part of Haskell hacking for me

Future Work

- Hoogle 4 final release
- Integration with Cabal/Hackage (search your packages and all packages)
- AJAX style interface
- Ranking/search tweaks

- Hoogle 4 is substantially faster and gives pretty good search results

Conclusions

- Type and Name search are useful for learning and developing
  - Type search is a lot harder to do
- Having a practical online search engine is a real bonus

Funny Searches

- eastenders
- california public schools portable classes
- Bondage
- diem chuan truong dai hoc su pham ha noi 2008
- Messenger freak
- ebay consistency version
- Simon Peyton Jones Genius
- free erotic storeis
- videos pornos gratis
- gia savores de BARILOCHE
- name of Peanuts carton bird
- Colin Runciman