Semantic Search for Quantity Expressions

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- Motivation: Problem and State Of The Art

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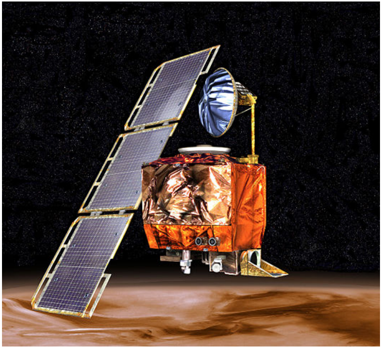
  - Mars Climate Orbiter (1999)



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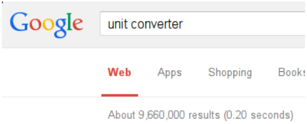

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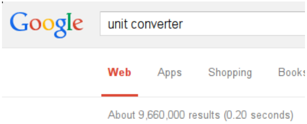
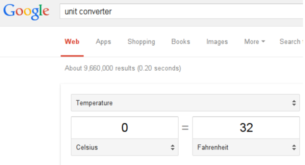


  - Google itself has one integrated



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- This is the kind of search engine we have built

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- Spotter is done by *Stiv Sherko*

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Our Approach: The Unit System (3) - A Theory of Dimensions

Dimension		
dim	:	type
none	:	dim
count	:	dim
length	:	dim
mass	:	dim
time	:	dim
current	:	dim
temperature	:	dim
luminous	:	dim
amount	:	dim
$\cdot$	:	dim $\rightarrow$ dim $\rightarrow$ dim
$/$	:	dim $\rightarrow$ dim $\rightarrow$ dim

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  5. *Quotient* of two existing QEs such as 1 $\frac{\text{Meter}}{\text{Second}}$
  6. *Sum* of two existing QEs

Our Approach: The Unit System (5) - A Theory of Quantity Expressions

Quantity Expression		
import Dimension		
QE	:	$\text{dim} \to \text{type}$
QENMul	:	$\forall x : \text{dim}.\mathbb{R} \to \text{QE}(x) \to \text{QE}(x)$
QENDiv	:	$\forall x : \text{dim}.\text{QE}(x) \to \mathbb{R} \to \text{QE}(x)$
QEAdd	:	$\forall x : \text{dim}.\text{QE}(x) \to \text{QE}(x) \to \text{QE}(x)$
QEMul	:	$\forall x, y : \text{dim}.\text{QE}(x) \to \text{QE}(y) \to \text{QE}(x \cdot y)$
QEDiv	:	$\forall x, y : \text{dim}.\text{QE}(x) \to \text{QE}(y) \to \text{QE}\left(\frac{x}{y}\right)$

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Non SI Lengths
import Quantity Expression
Thou : QE (length) Foot = QENMul (1000, Thou) Yard = QENMul (3, Foot) Chain = QENMul (22, Yard) Furlong = QENMul (10, Chain) Mile = QENMul (8, Furlong)

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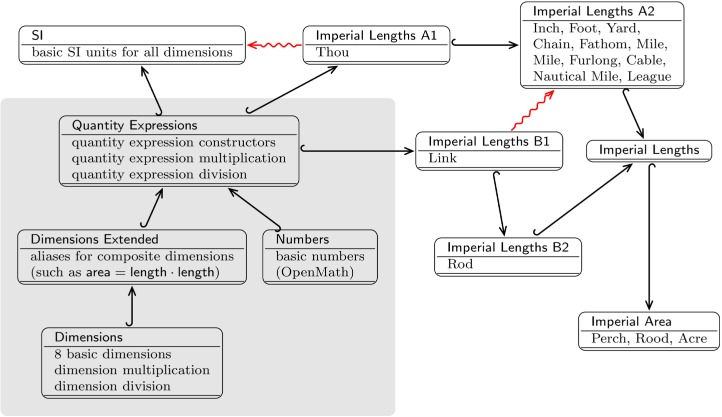
  - allows conversion

Our Approach: The Unit System (6) - Part of the unit Theory Graph



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- *Goal*: Find all QEs equivalent to query
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- *Idea*: bring QEs to normal form and use efficient indexing

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- Furlong $=$ 10 Chain $=$ 10 (22 Yard) $= \cdots =$ 10 (22 (3 (12 (1000 (0.0000254 Meter)))))
- Fortnight $=$ (2 (7 (24 (60 (60 Second)))))
- Substitute this back into the original expression
- $42\frac{10(22(3(1000(0.0000254\ \text{Meter}))))}{2(7(24(60(60\ \text{Second}))))}$

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- $42\frac{10(22(3(1000(0.0000254\ \text{Meter}))))}{2(7(24(60(60\ \text{Second}))))}$
- Then extract the *scalar* component and compute it:

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- $42 \frac{10(22(3(1000(0.0000254\ \text{Meter}))))}{2(7(24(60(60\ \text{Second}))))}$
- Then extract the *scalar* component and compute it:
- $42 \frac{10(22(3(12(1000(0.0000254)))))}{2(7(24(60(60))))} = 0.006985$

Our Approach: The Search Algorithm (3)

- Example: Normalise $42\frac{\text{Furlong}}{\text{Fortnight}}$
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- We normalise to SI units here, but we can freely choose

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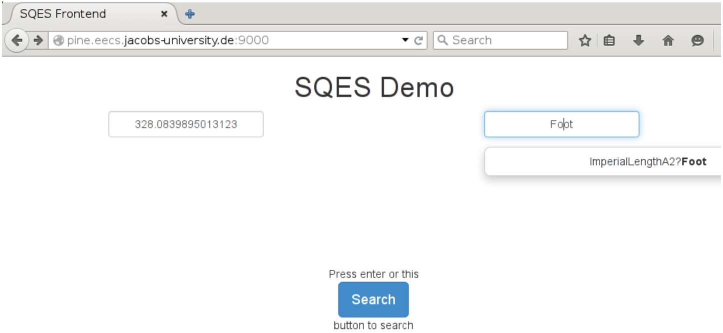
Conclusion: The Implementation (3)



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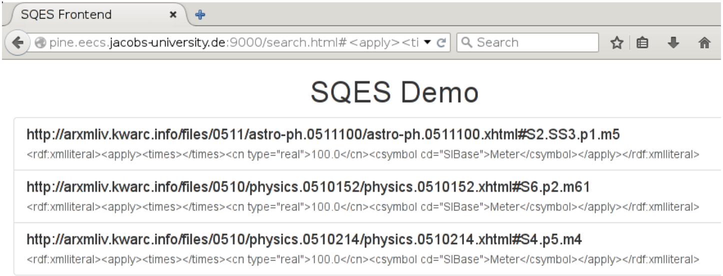

Time for Questions

Thank You For Listening!

Image sources:

- http://www.gettingaroundgermany.info/g_imgs/z274.gif
- http://upload.wikimedia.org/wikipedia/commons/thumb/1/19/Mars_Climate_Orbiter_2.jpg/528px-Mars_Climate_Orbiter_2.jpg