Intro to C++ with R

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Overview

1. Overview of High Performance Computing/Big Data Analytics in R.
2. Programming Choices
3. Paralellization/Memory Management Example
4. C++ Example.
5. Big Data Example.

Rcpp and RcppArmadillo

1. Rcpp is integrated with RStudio – easy C++ coding

2. RcppArmadillo – gives you access to linear algebra libraries.

3. Shallow vs. deep data structures.

4. Best for sampling and looping.

Basic RcppArmadillo C++ function

```
#include <RcppArmadillo.h>
#include <string>
//[[Rcpp::depends(RcppArmadillo)]]
using namespace Rcpp;
//[[Rcpp::export]]
List My_Function(
    int some_number,
    List some_vectors,
    arma::vec a_vector,
    arma::mat example_matrix
    ){
        ...
        List to_return(1);
        to_return[0] = some_data;
        return to_return;
     }
```

Looping + Conditionals (ex. word counter)

```
for(int n = 0; n < number_of_bills; ++n){
  report(n);
  int length = Bill_Lengths[n];
  std::vector<std::string> current = Bill_Words[n];
  for(int i = 0; i < length; ++i){
    int already = 0;
    int counter = 0;
    while(already == 0){
      if(unique_words[counter] == current[i]){
        unique_word_counts[counter] += 1;
        already  = 1;
      }
      counter +=1;
    }
  }
}
```

Drawing Random Numbers

```
// add to second and third lines of file
#include <random>
#include <math.h>

// set RNG and seed
std::mt19937_64 generator(seed);

// define a uniform distribution and draw from it
std::uniform_real_distribution<double> udist(0.0, 1.0);
double rand_num = udist(generator);

// define a normal distribution and draw from it
std::normal_distribution<double> ndist(mu,sigsq);
my_matrix(k,b) = ndist(generator);
```

Other Useful Stuff

```
# In R define
Report <- function(string){print(string)}

// In C++ we write (inside function definition)
Function report("Report");

// now we can print stuff back up to R
report(n);

// initialize a vector/matrix to zeros
arma::vec myvec = arma::zeros(len);

// some math operators
double d = exp(log(pow(2,4)));
```

Things to watch out for

1. Use Armadillo data structures – Rcpp data structures can overflow memory.
2. Cast integers as doubles before dividing.
3. Low latency + faster looping = 50-2,000x speedup.
4. For Linux systems:

```
PKG_CPPFLAGS = "-std=c++11"
Sys.setenv(PKG_CPPFLAGS = PKG_CPPFLAGS)
```

5. Big Data Example

Congressional Bill Text

1. 90,867 final versions of bills introduced in the U.S. Congress form 1993-2012.

2. 293,697,605 tokens (370,445 unique).

3. 90 covariates for every bill.

4. Addition data on amendments, cosponsorships, and floor speeches.

Lets Look at Some Bill Text

This Act may be cited as the ‘‘EPA Science Act of 2014’’.

.....

SEC. 2. SCIENCE ADVISORY BOARD.

(a) Independent Advice.--Section 8(a) of the Environmental Research, Development, and Demonstration Authorization Act of 1978 (42 U.S.C. 4365(a)) is amended by inserting ‘‘independently’’ after ‘‘Advisory Board which shall’’.

(b) Membership.--Section 8(b) of the Environmental Research, Development, and Demonstration Authorization Act of 1978 (42 U.S.C. 4365(b)) is amended to read as follows:

‘‘(b)(1) The Board shall be composed of at least nine members, one of whom shall be designated Chairman, and shall meet at such times and places as may be designated by the Chairman.

‘‘(2) Each member of the Board shall be qualified by education, training, and experience to evaluate scientific and technical ....

Taxonomy of Bill Text

Category	Definition	Example
Substantive Language	Confers the intent of a piece of legislation or a particular provision.	{**restrict abortion**}, {**reduce the deficit**}
Topical Language	Confers information about the subject of the Bill.	{alternate academic achievement standards}
Boilerplate	Gives direction about legal interpretation or implementation.	{Notwithstanding any other provision of this paragraph...}
Domain Stopwords	Gives no information about intent, legal interpretation or implementation.	{SECTION}, {(c) Title III.–}, {(1) Part a.–}, {(A) Subpart 1.–}, {to adopt}

Lets Look at N-Grams

Unit of Analysis	Topical Text
Tokens	{Should}, {a}, {Federal}, {agency}, {seek}, {to}, {**restrict**}, {**photography**}, {of}, {its}, { installations}, {or}, {personnel}, {it}, {shall}, {obtain}, {a}, {**court**}, {order}, {that}, {outlines}, { the}, {national}, {**security**}, {or}, {other}, {reasons}, {for}, {the}, {restriction}
Bigrams	{Should a}, {a Federal}, {Federal agency}, {agency seek}, {seek to}, {to restrict}, {**restrict photography**}, {photography of}, {of its}, {its installations}, {installations or}, {or personnel}, {personnel it}, {it shall}, {shall obtain}, {obtain a}, {a court}, {**court order**}, {order that}, {that outlines}, {outlines the}, {the national}, {**national security**}, {security or}, {or other}, {other reasons}, {reasons for}, {for the}, {the restriction}

Justeson and Katz Filtering

Tag Pattern	Example
AN	*linear function*
NN	*regression coefficients*
AAN	*Gaussian random variable*
ANN	*cumulative distribution function*
NAN	*mean squared error*
NNN	*class probability function*
NPN	*degrees of freedom*

Add in verbs to capture intent...

Tag Pattern	Example
VN	*reduce funding*
VAN	*encourage dissenting members*
VNN	*restrict federal agencies*

J&K Filtering and Phrase Extraction

Unit of Analysis	Topical Text – Verb Phrase Additions
J&K Filtered Bigrams	{Federal agency}, {**restrict photography**}, {**court order**}, {**national security**}, {other reasons}
J&K Filtered Trigrams	NONE
Noun Phrases	{Federal agency}, {**court order**}, {**national security**},{other reasons},{**other reasons for the restriction**}

Constructing a Document-Term Matrix

- Want Document x Vocabulary matrix.
- Take advantage of sparsity.
- Use C++ for indexing.
- Have to chunk and add.

Constructing a Document-Term Matrix

```
# gives us simple triplet matrix class
library(slam)

# load in C++ function to generate rows in matrix
Rcpp::sourceCpp('Document_Word_Compiler.cpp')

for(i in 1:chunks){
  dwm <- Generate_Document_Word_Matrix(chunk,..)
  dwm <- as.simple_triplet_matrix(dwm)
  if(j == 1){
    swm <- dwn
  }else{
    swm <- rbind(swm,dwm)
  }
}
```

Semi-Supervised Major Topic Tags

Category
1. Macroeconomics
2. Civil Rights, Minority Issues, and Civil Liberties
3. Health
4. Agriculture
5. Labor and Employment
6. Education
7. Environment
8. Energy
9. Immigration
10. Transportation
12. Law, Crime, and Family Issues
13. Social Welfare
14. Community Development and Housing Issues
15. Banking, Finance, and Domestic Commerce
16. Defense
.....

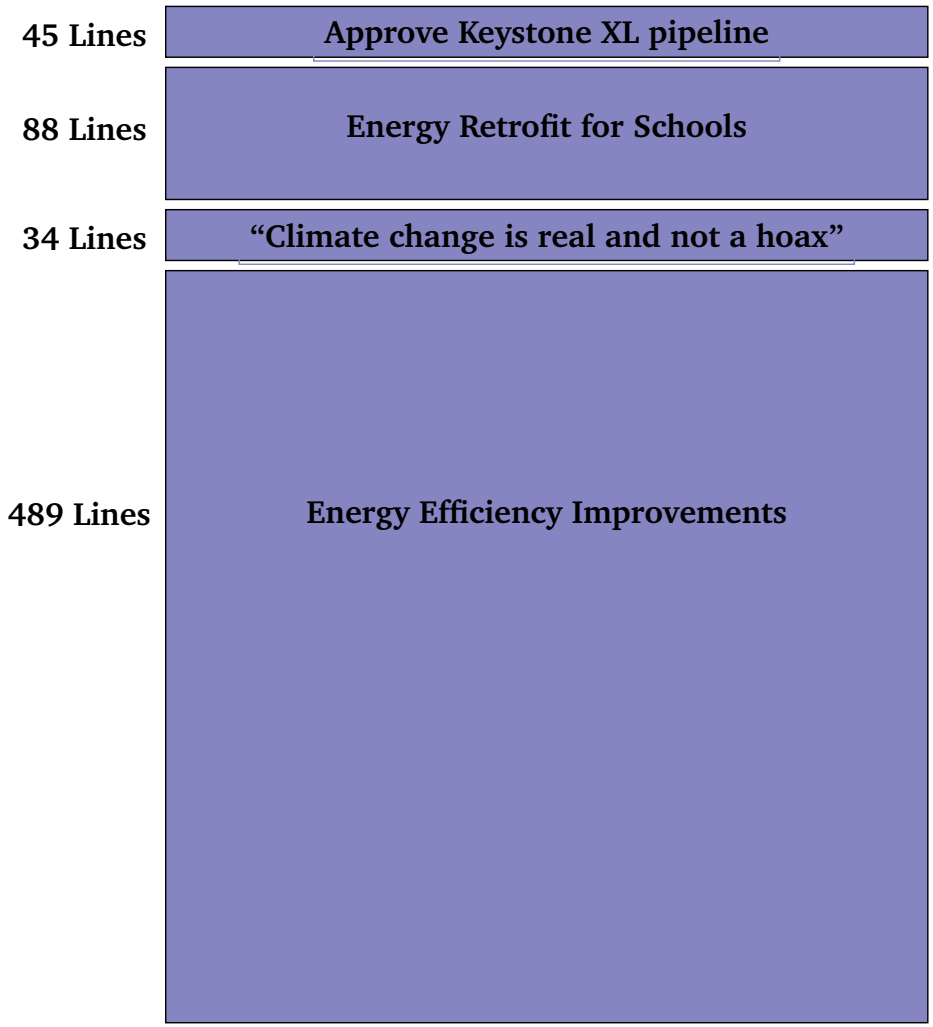
J&K Filtered Trigrams for Identifying Topical Area

Health

Word	PMI	Local	Global
stay	1.754	24425	26428
start	1.689	12395	14321
enhance	1.684	22142	25707
providers	1.684	51656	59976
mining	1.679	15221	17751

Filtered Trigram	PMI	Local	Global
health insurance plan	1.340	868	1528
health benefit plan	1.306	1125	2049
term care insurance	1.292	3564	6577
health plan means	1.110	261	578
alternative dispute resolution	1.079	923	2108

Unit of Analysis? – Keystone XL Pipeline Approval Act



Down the Road

1. Average conditional mutual information vocabulary partitioning.
2. Political branding and meme-detection.
3. Text/Networks
4. More super secret tech :)

Big Data Challenges

1. Extending R vectors/matricies beyond 2.1 billion elements.

2. More low level datastructures – linked list, queue, stack, etc.

3. Better garbage collection.

4. More lazy/greedy/approximate methods.