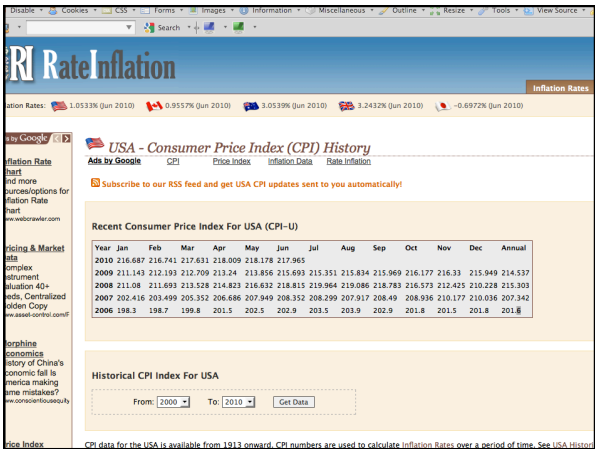
Web Technologies
Accessing Data

Topics

- HTML pages
- XPath
- HTML forms
- REST
- SOAP
- XML-RPC
- (You don't have to teach them all, but there are interesting aspects to all.)

Consumer Price Index

- Suppose we have a financial time series and need to adjust for inflation.
  We need the CPI values for the relevant period.
- We can look this up on the Web, e.g.
  - http://www.rateinflation.com/consumer-price-index/usa-historical-cpi.php



- The data for the most recent 5 years is in the main table.
- There is also an HTML form that allows the reader to specify the interval of interest. We'll return to this.

- How to read the data for the 5 years for each month?
- Simple answer: readHTMLTable() in the XML package.
- tbls = readHTMLTable("http://www.rateinflation.com/consumer-price-index/usa-historical-cpi.php")
- length(tbls)
- sapply(tbls, nrow)
- We want the last one – 6 rows, including the header.

- cpi = readHTMLTable("http://www.rateinflation.com/consumer-price-index/usa-historical-cpi.php",
  which = 11, header = TRUE)
- Fix up the types of each column, converting from a factor to a number.
- cpi= as.data.frame(
  lapply(cpi,
  function(x)
  as.numeric(as.character(x)))

Details

- Interesting answer is how that function is implemented
- Examine the HTML
  - find all <table> elements
  - process each of these to convert to a data frame
    - find <tr> elements for each row
    - recognize <th> elements or <thead> for header
    - <td> for data value
    - Unravel into data.frame
- Details in the XML package and readHTMLTable()
- But general concepts in Xpath and finding <table> nodes.

XPath

- Xpath is yet another DSL – domain specific language
- XML documents are trees and Xpath is a mechanism for finding nodes anywhere within the tree based on a "pattern"
- Pattern is a path that identifies sequence of nodes by
  - direction or "axis" (parent, child, ancestor, descendant, sideways (<- ->))
  - node test – i.e. the name (e.g. table, thead, tr, td)
  - predicate test (has an attribute href, has an attribute href = "foo")

- Parse the XML/HTML document
  - doc = htmParse ("http://www.rateinflation.com/consumer-price-index/usa-historical-cpi.php")
- Find the <table> elements
  tbls = getNodeSet(doc, "//table")
- getNodeSet() takes a document or a node and searches through the sub-tree using a language for describing how to find the nodes of interest.

- // is srt-hand for "/descendant::table",
  / is the top-level/root node
  descendant is an "axis"
  table is the node-test
- If the <table> of interest had an id attribute, we could add a predicate, e.g.
  - getNodeSet(doc, "//table[@id='cpi']")

- getNodeSet() returns a list of matching nodes.
- We can then recursively extract the nodes of interest, e.g. the <tr> and the <td> elements
  - can walk the tree ourselves if shallow
  - or use getNodeSet() to query the subtree easily
- Convert the values in these sub-nodes to R values and combine into data structure.

Walking the tree

- A node has a name
  - xmlName(node)
- Attributes
  - xmlAttrs(node), xmlGetAttr(node, "attrName")
- Children
  - xmlChildren(node) – list of child nodes
- Parent node
  - xmlParent(node)

- rows = getNodeSet(tbl, ".//tr") do.call("rbind", lapply(rows, getRowValues))
- getRowValues gets all the <td> within a <tr> xpathSApply(row, ".//td", xmlValue)

- Xpath is similar to regular expressions
  - It is a way of expressing complex patters very tersely and having the Xpath engine implement the search.
- Works for any XML document, so very general.
- Can build up very precise or general queries
  - contextual knowledge important to catch all the nodes we want, but no more.
- We use Xpath for processing XML from many different sources.

Back to the HTML form

- What if we want more or different years?
  - Use the HTML form?
- But how can we mimic selecting the Start and End years from within R, i.e. programmatically?
- An HTML form is like an R function
  - takes inputs, returns an result – an HTML document
- Need to mimic a Web browser to pass arguments to Web server.

RCurl

- The RCurl package provides an R interface to a very general and powerful library that can perform Web queries programmatically and that are very customizable.
- 3 main functions:
  - getURLContent()
  - getForm()
  - postForm()

- Similar functionality to download.url(), but much more customizable and general
- Can handle
  - Secure HTTP – https
  - cookies, passwords
  - many additional important options
  - maintain state across requests
  - multiple concurrent requests

- Examine HTML document and look for the <form>.
  Find the parameter names and use these as named parameters in getForm()
- x = postForm("http://www.rateinflation.com/consumer-price-index/usa-historical-cpi.php",
  form = "usacpi",
  fromYear = "1945",
  toYear = "1965",
  `_submit_check` = "1")
- Then pass this to readHTMLTable(), which =

REST

- Representational State Transfer
- URL represents a state which can be queried or even updated via remote calls/queries.
- Send parameterized Web query via getForm()
  - specify URL
  - name value pairs for parameters
- Get back a "document"
  - may be
    - raw text
    - XML
    - JSONIO
    - binary data

Process result

- Raw text – use text manipulation, regular expressions, connections to read into R object
- JSON – JavaScript Object Notation
  - use RJSONIO or rjson
- XML – parseXML() and Xpath (getNodeSet())
- Binary data – treat as is, or if compressed, uncompress in-memory via Rcompression

Zillow

- Zillow provides information and price estimates of homes
- REST API info at http://www.zillow.com/howto/api/APIOverview.htm
- Register to get a Zillow Web Service ID (ZWSID) that you pass in each call to a Zillow API method

- Call GetZEstimate for a property giving street address
  - getForm("http://www.zillow.com/webservice/GetSearchResults.htm",
    `zws-id` = ZWSID,
    address = "1292 Monterey Ave",
    citystatezip = "Berkeley, CA")

    Result is a text string which contains an XML document

Getting the Result Info

- XML contains <request>, <message>, <response>
- Extract property id, price estimate, lat./long., comparables link, etc.
- Use Xpath and xmlValue().
- doc = xmlParse(txt, asText = TRUE)
- est = doc[["//result/zestimate"]]
- as.numeric(xmlValue(est[["amount"]]))

- R package Zillow provides functions for several of the API methods and hides all the details.

Yahoo Search

- Yahoo Web Search Service
  - http://developer.yahoo.com/search/web/V1/webSearch.html
- out = getForm("http://search.yahooapis.com/WebSearchService/V1/webSearch",
  appid = yahooAppIdString,
  query = "REST XML Yahoo",
  results = 100,
  output = "json")

- library(RJSONIO)
- ans = fromJSON(out)
- ans is a list with 1 element named ResultSet
- length(ans$ResultSet) # 6
- names(ans$ResultSet)
- [1] "type" "totalResultsAvailable"
  [3] "totalResultsReturned" "firstResultPosition"
  [5] "moreSearch" "Result"

Individual Search Result Item

- names(ans$ResultSet$Result[[1]])
- [1] "Title" "Summary" "Url"
  [4] "ClickUrl" "DisplayUrl" "ModificationDate"
  [7] "MimeType" "Cache"

REST

- Pros:
  - simple and easy to get started
  - natural exploitation of URLs as resources
- Cons:
  - cannot send or retrieved complex/hierarchical data structures
  - have to process result manually
  - have to find methods and inputs manually by reading documentation.
    - Do this once and build R functions to hide the details.

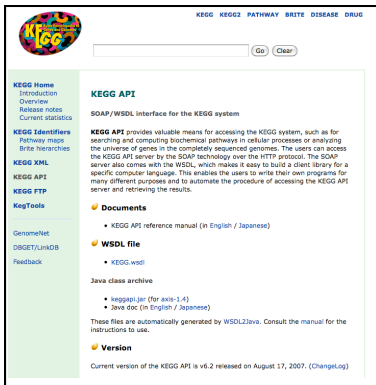
- GoogleDocs
- EBI
- Flickr
- Twitter
- Zillow
- NY Times
- Google Trends
- MusicBrainz
- LastFM
- …
- R packages for several of these

SOAP

- Simple Object Access Protocol
- Richer and more complex than REST
  - can send highly structured data via XML
  - Send request in an Envelope containing a request to invoke a method in the server's object
    - Send arguments as self-describing objects
- SOAP allows us to define new data types and structures
  - application specific data types

SOAP

- Would have to construct the SOAP request
  - the envelop and the message
  - Too many details to do manually.
- Instead, SOAP service publishes a description of its methods and data types
  - WSDL document – Web Service Description Language
- Code reads this and generates R functions to invoke each of the methods, coercing the R arguments to their XML representation and converting the XML result to an R object.
- Transparent to user



Kyoto Encyclopedia of Genes and Genomes provides a SOAP Web Service (among other services) to access its system functionality (API)

http://www.genome.jp/kegg/soap/

From R

- library(SSOAP)
- u = "http://soap.genome.jp/KEGG.wsdl"
- kegg.wsdl = processWSDL(u)
- kegg.iface = genSOAPClientInterface(, kegg.wsdl)
- Now we have an S4 object containing class definitions and a list of functions
- names(kegg.iface@functions)

- Invoke the list_databases method
  - kegg.iface@functions$list_databases()
  - returns a list of S4 Definition objects
  - e.g. An object of class "Definition"
    Slot "entry_id":
    [1] "nt"
    Slot "definition":
    [1] "Non-redundant nucleic acid sequence database"

- Get enzymes for a specific gene id
- iface@functions$get_enzymes_by_gene('eco:b0002')
  - [1] "ec:1.1.1.3" "ec:2.7.2.4"