RNetica

Quick Start Guide

Scoring A Student

Downloading

- http://pluto.coe.fsu.edu/RNetica/
- Four Packages:
  - RNetica – R to Netica link
  - CPTtools – Design patterns for CPTs
  - Peanut/PNetica -- Object-Oriented Parameterized Network
- Source & binary version (Win 64, Mac OS X)
  - Binary versions include Netica.dll/libNetica.so
    - In RStudio select "Package Archive" rather than CRAN
  - Source version need to download from http://www.norsys.com/ first
    - See INSTALLATION

License

- R – GPL-3 (Free and open source)
- RNetica – Artistic (Free and open source)
- Netica.dll/libNetica.so – Commercial (open API, but not open source)
  - Free Student/Demo version
    - Limited number of nodes
    - Limited usage (education, evaluation of Netica)
  - Paid version (see http://www.norsys.com/ for price information)
    - Need to purchase API not GUI version of Netica
    - May want both (use GUI to visualize networks build in RNetica)
- CPTtools – Artistic (Free and open source), does not depend on Netica

Installing the License Key

- When you purchase a license, Norsys will send you a license key. Something that looks like: "+Course/FloridaSU/Ex15-05-30,120,310/XXXXX" (Where I've obscured the last 5 security digits)
- To install the license key, start R in your project directory and type:

```
> DefaultNeticaSession <-
NeticaSession(LicenseKey="+Course/FloridaSU/
Ex15-05-30,120,310/XXXXX")
> q("yes")
```

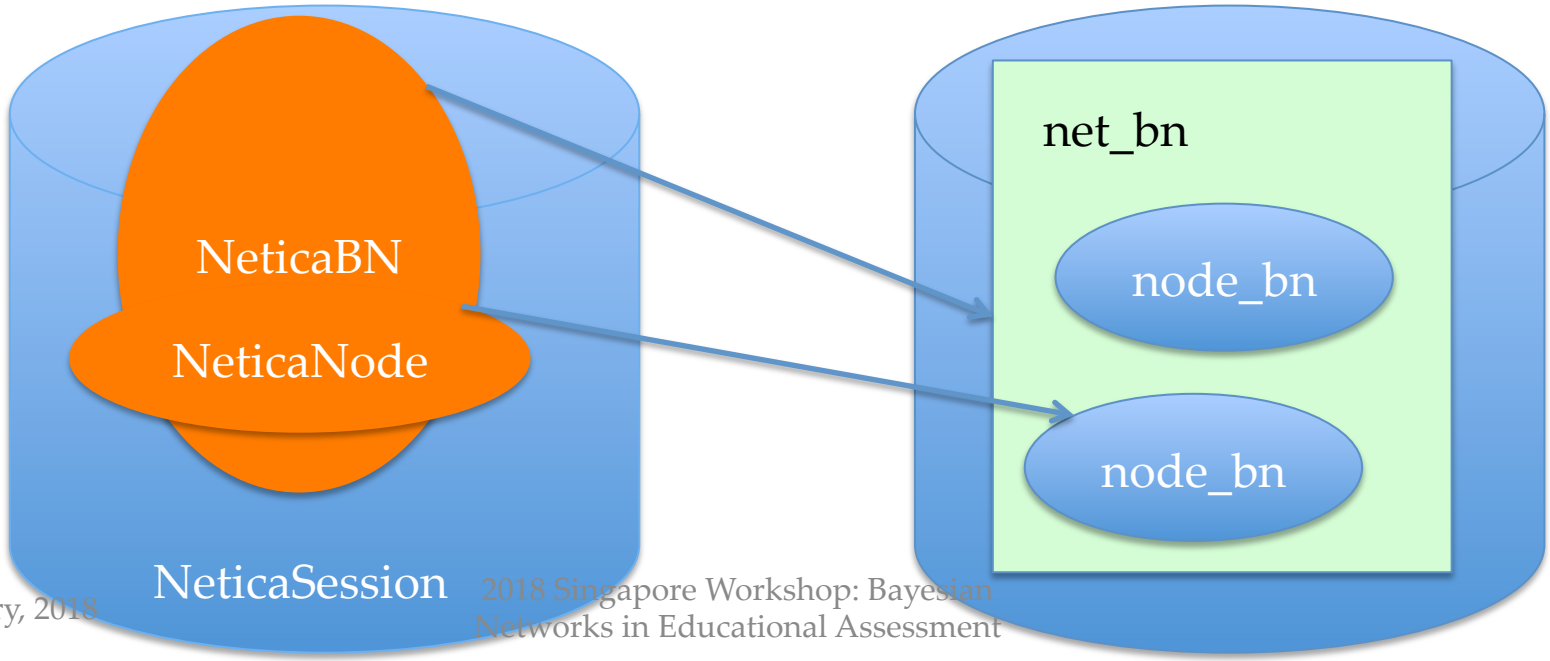
- Restart R and type

```
> library(RNetica)
>  startSession(DefaultNeticaSession)
```

- If license key is not installed, then you will get the limited/student mode. Most of these examples will run

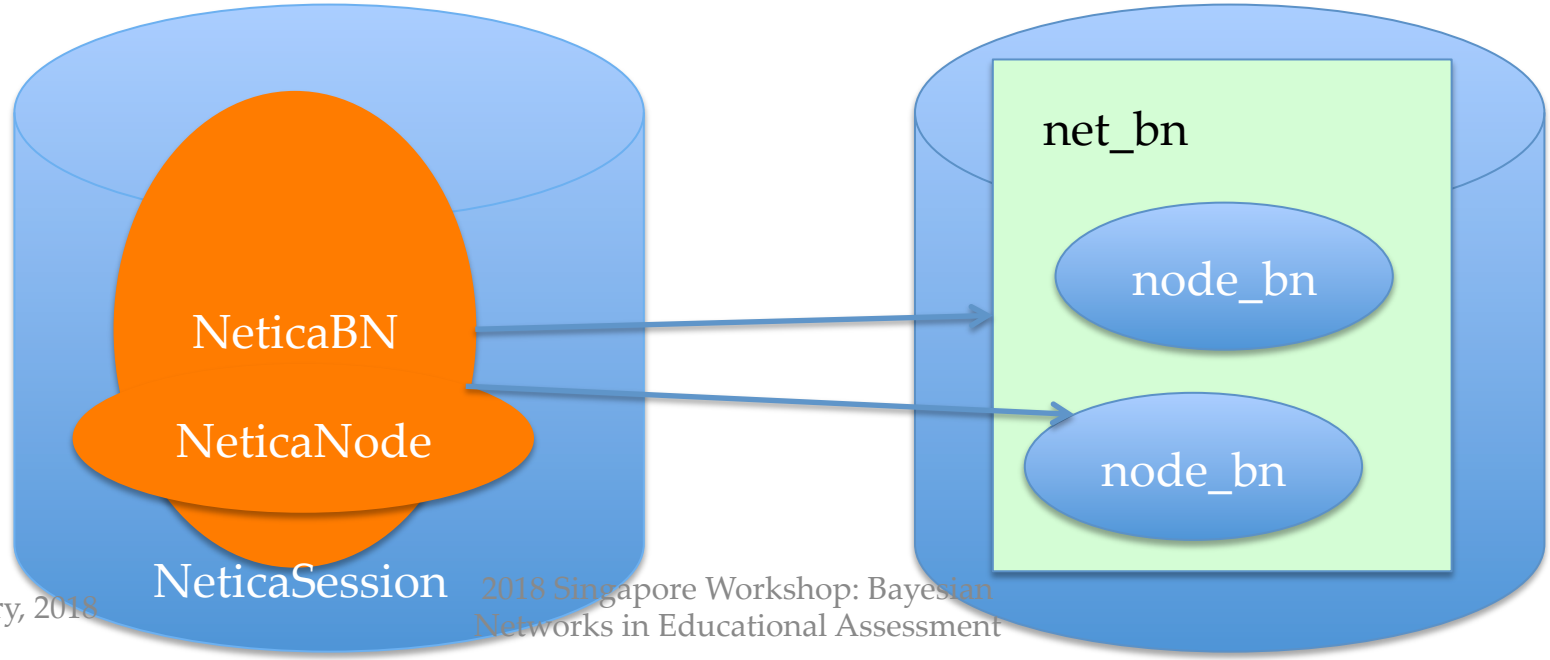
The R heap and the Netica heap

- R and Netica have two different workspaces (memory heaps)
- R workspace is saved and restored automatically when you quick and restart R.
- Netica heap must be reconnected manually.



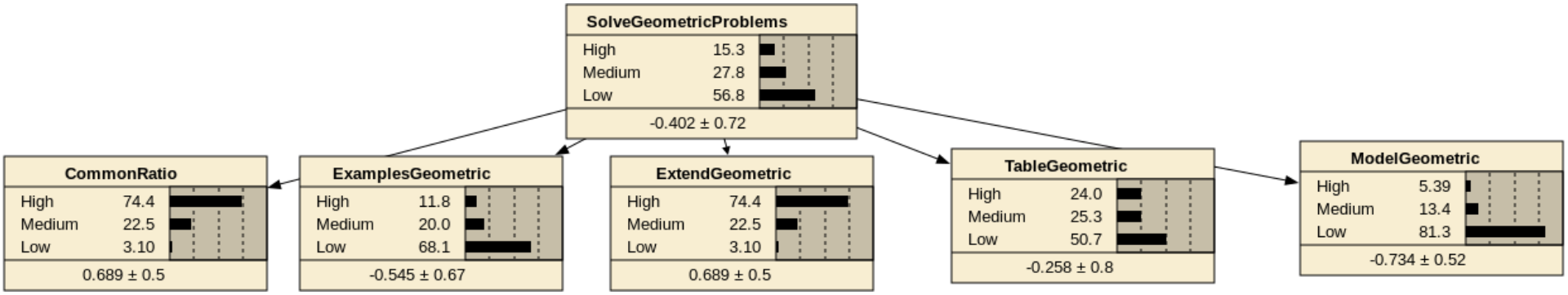
Active and Inactive pointers

- When RNetica creates/finds a Netica object it creates a corresponding R object
- R NeticaBN objects live in the NeticaSession object. R NeticaNode objects live in the NeticaBN.
- If the pointer gets broken (saving & restarting R, deleting the network/node) then the R object becomes inactive.
- The function is.active() test to see if the node/net/session is active



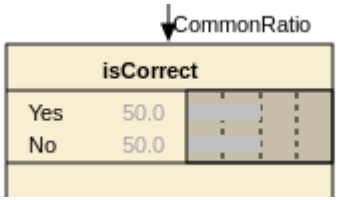
Mini-ACED Proficiency model

- Subset of ACED network (Shute, Hansen & Almond (2008); http://ecd.ralmond.net/ecdwiki/ACED)
- Proficiency Model subset:

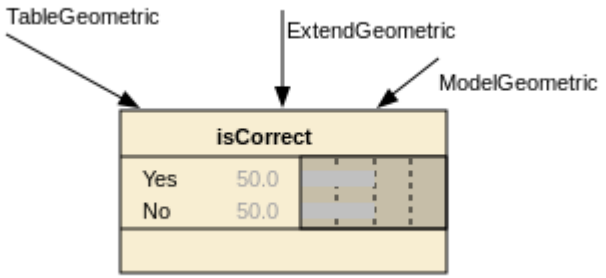


Mini-ACED EM Fragments

- All ACED tasks were scored correct/ incorrect
- Each evidence model is represented by a fragment consisting of observables with *stub* edges indicating where it should be *adjoined* with the network.



Common Ratio Easy



Model Extend Table Hard

Task to EM map

- Need a table to tell us which EM to use with which task

Task ID	EM Filename	X	Y
tCommonRatio1b	CommonRatioEasyEM	108	414
tCommonRatio2a	CommonRatioMedEM	108	534
tCommonRatio2b	CommonRatioMedEM	108	654
tCommonRatio3a	CommonRatioHardEM	108	774
tCommonRatio3b	CommonRatioHardEM	108	894
tExamplesGeometric1a	ExamplesEasyEM	342	294
tExamplesGeometric1b	ExamplesEasyEM	342	414

Scoring Script

- Follow along using the script found in `ScoringScript.R` in the miniACED folder.
- Don't forget to `setwd()` to the miniACED folder (as it needs to find its networks).
- Don't forget to start the Netica session using the license key (if you have one).

Loading and starting the Session

```
## Scoring Script
## Preliminaries
library(RNetica)
library(CPTtools)

## start the session
sess <- NeticaSession(<key>)
startSession(sess)
```

Reloading Nets and Nodes

```
## Read in network - Do this every time R is restarted
profModel <- ReadNetworks("miniACEDPnet.dne")
## If profModels already exists could also use

## Reconnect nodes - Do this every time R is restarted
allNodes <- NetworkAllNodes(profModel)
sgp <- allNodes$SolveGeometricProblems
profNodes <- NetworkNodesInSet(profModel,"Proficiencies")
```

Aside 1: Node Sets

- Netica defines a node set functionality which
  - Adds a collection of labels (sets) to each node
  - Defines a collection of nodes with that label
- Netica GUI really only offers the opportunity to color nodes by set
- RNetica can loop over node sets (lists of nodes)

```
## Node Sets
NetworkNodeSets(profModel)
NetworkNodesInSet(profModel,"pnodes")
NodeSets(sgp)

## These are all settable
NodeSets(sgp) <- c(NodeSets(sgp),"HighLevel")
NodeSets(sgp)
```

Aside 2: RNetica Functions

```
## Querying Nodes
NodeStates(sgp)    #List states
NodeParents(sgp)   #List parents
NodeLevels(sgp)    #List numeric values associated with
states
NodeProbs(sgp) # Conditional Probability Table (as array)
sgp[] # Conditional Probability Table (as data frame)
## These are all settable (can be used on RHS of <-) for
## model construction

## Inference
CompileNetwork(profModel) #Lightning bolt on GUI
## Must do this before inference
## Recompiling an already compiled network is harmless
```

Aside 2: Inference

```
## Enter Evidence by setting values for these
functions
NodeValue(sgp) #View or set the value
NodeLikelihood(sgp) #Virtual evidence

## Query beliefs
NodeBeliefs(sgp) #Current probability (given entered
evidence)
NodeExpectedValue(sgp) #If node has values, EAP
## These aren't settable

## Retract Evidence
RetractNodeFinding(profNodes$ExamplesGeometric)
RetractNetFindings(profModel)
```

Aside 2: Example

```
## Enter Evidence
NodeValue(profNodes$CommonRatio) <- "Medium"
## Enter Evidence "Not Low" ("High or Medium")
NodeLikelihood(profNodes$ExamplesGeometric) <-
c(1,1,0)

NodeBeliefs(sgp) #Current probability (given entered
evidence)
NodeExpectedValue(sgp) #If node has values, EAP

## Retract Evidence
RetractNetFindings(profModel)

## Many more examples
help(RNetica)
```

Back to work

- Load the evidence model table
- Row names are task IDs
- EM column contains evidence model name
- EM filename has suffix "`.dne`" attached.

```
## Read in task->evidence model mapping
EMtable <-
read.csv("MiniACEDEMTable.csv",row.names=1,
                        as.is=2) #Keep EM names
as strings
head(EMtable)
```

A student walks into the test center …

- Student gives the name "Fred"
- Student is the right grade/age for ACED (8^{th} or 9^{th} grader, pre-algebra)
- Bayes net has three states
  - Fred logs into ACED
  - Fred attempts the task `tCommonRatio1a` and gets it right
  - Fred attempts the task `tCommonRatio2a` and gets it wrong

Start a new student

```
## Copy the master proficiency model
## to make student model
Fred.SM <- CopyNetworks(profModel,"Fred")
Fred.SMvars <- NetworkAllNodes(Fred.SM)
CompileNetwork(Fred.SM)

## Setup score history
prior <-
NodeBeliefs(Fred.SMvars$SolveGeometricProblems)
Fred.History <- matrix(prior,1,3)
row.names(Fred.History) <- "*Baseline*"
colnames(Fred.History) <- names(prior)
Fred.History
```

Score 1st Task

```
### Fred does a task
t.name <- "tCommonRatio1a"
t.isCorrect <- "Yes"

## Adjoin SM and EM
EMnet <-
ReadNetworks(paste(EMtable[t.name,"EM"],"dne",sep=".
"))
obs <- AdjoinNetwork(Fred.SM,EMnet)
NetworkAllNodes(Fred.SM)
## Fred.SM is now the Motif for the current task.
CompileNetwork(Fred.SM)

## Enter finding
NodeFinding(obs$isCorrect) <- t.isCorrect
```

Stats and Cleanup for 1st task

```
## Calculate statistics of interest
post <-
NodeBeliefs(Fred.SMvars$SolveGeometricProblems)
Fred.History <- rbind(Fred.History,new=post)
rownames(Fred.History)[nrow(Fred.History)] <-
paste(t.name,t.isCorrect,sep="=")
Fred.History

## Cleanup and Observable no longer needed, so
absorb it:
DeleteNetwork(EMnet) ## Delete EM
##AbsorbNodes(obs)
## Currently, there is a Netica bug with Absorb
Nodes, we will leave
## this node in place as that is mostly harmless.
```

2nd Task

```
### Fred does another task
t.name <- "tCommonRatio2a"
t.isCorrect <- "No"

EMnet <- ReadNetworks(paste(EMtable[t.name,"EM"],"dne",sep="."))
obs <- AdjoinNetwork(Fred.SM,EMnet)
NetworkAllNodes(Fred.SM)
## Fred.SM is now the Motif for the current task.
CompileNetwork(Fred.SM)

NodeFinding(obs[[1]]) <- t.isCorrect
post <- NodeBeliefs(Fred.SMvars$SolveGeometricProblems)
Fred.History <- rbind(Fred.History,new=post)
rownames(Fred.History)[nrow(Fred.History)] <-
      paste(t.name,t.isCorrect,sep="=")
Fred.History

## Cleanup:  Delete EM and Absorb observables
DeleteNetwork(EMnet) ## Delete EM
## AbsorbNodes(obs)
```

Save and Restore

```
## Fred logs out
WriteNetworks(Fred.SM,"FredSM.dne")
DeleteNetwork(Fred.SM)
is.active(Fred.SM)
## No longer active in Netica space

## Fred logs back in
Fred.SM <- ReadNetworks("FredSM.dne")
is.active(Fred.SM)
```

Getting Serious

- ACED field test has 230 students attempt all 63 tasks.
- File miniACED-Geometric contains 30 task subset
  - There may be data registration issues here, don't publish using these data before checking with me for an update
- Each row is one student Record
- Lets score the first student
  - And build a score history

Setup for mini-ACED

```
miniACED.data <- read.csv("miniACED-
Geometric.csv",row.names=1)
head(miniACED.data)
names(miniACED.data)
## Mark columns of table corresponding
to tasks
first.task <- 9
last.task <- ncol(miniACED.data)
## Code key for numeric values
t.vals <- c("No","Yes")
```

Setup new Student

```
## Pick a student, we might normally iterate over this.
Student.row <- 1

## Setup for student in sample
## Create Student Model from Proficiency Model
Student.SM <- CopyNetworks(profModel,"Student")
Student.SMvars <- NetworkAllNodes(Student.SM)
CompileNetwork(Student.SM)

## Initialize history list
prior <-
NodeBeliefs(Student.SMvars$SolveGeometricProblems)
Student.History <- matrix(prior,1,3)
row.names(Student.History) <- "*Baseline*"
colnames(Student.History) <- names(prior)
```

Loop Part 1: Add Evidence

```
## Now loop over tasks
for (itask in first.task:last.task) {

  ## Look up the EM for the task, and adjoin it.
  tid <- names(miniACED.data)[itask]
  EMnet <-
ReadNetworks(paste(EMtable[tid,"EM"],"dne",sep="."))
  obs <- AdjoinNetwork(Student.SM,EMnet)
  CompileNetwork(Student.SM)

  ## Add the evidence
  t.val <- t.vals[miniACED.data[Student.row,itask]]
#Decode integer
  NodeFinding(obs[[1]]) <- t.val
```

Loop Part 2: Capture Statistics

```
## Update the history
  post <-
NodeBeliefs(Student.SMvars$SolveGeometricProblem
s)
  Student.History <-
rbind(Student.History,new=post)
  rownames(Student.History)
[nrow(Student.History)] <-
paste(tid,t.val,sep="=")

  ## Cleanup, Delete EM and Absob Observables
  DeleteNetwork(EMnet)
  ## AbsorbNodes(obs) # Still broken
}
```

Weight of Evidence

- Good (1985)
- *H* is binary hypothesis, e.g., *Proficiency* > Medium
- *E* is evidence for hypothesis
- Weight of Evidence (WOE) is

$$W(H:E) = \log \frac{\Pr(E|H)}{\Pr(E|\overline{H})} = \log \frac{\Pr(H|E)}{\Pr(\overline{H}|E)} - \log \frac{\Pr(H)}{\Pr(\overline{H})}$$

Conditional Weight of Evidence

- Can define Conditional Weight of Evidence

$$W(H : E_2|E_1) = \log \frac{\Pr(E_2|H, E_1)}{\Pr(E_2|\overline{H}, E_1)}$$

- Nice Additive properties

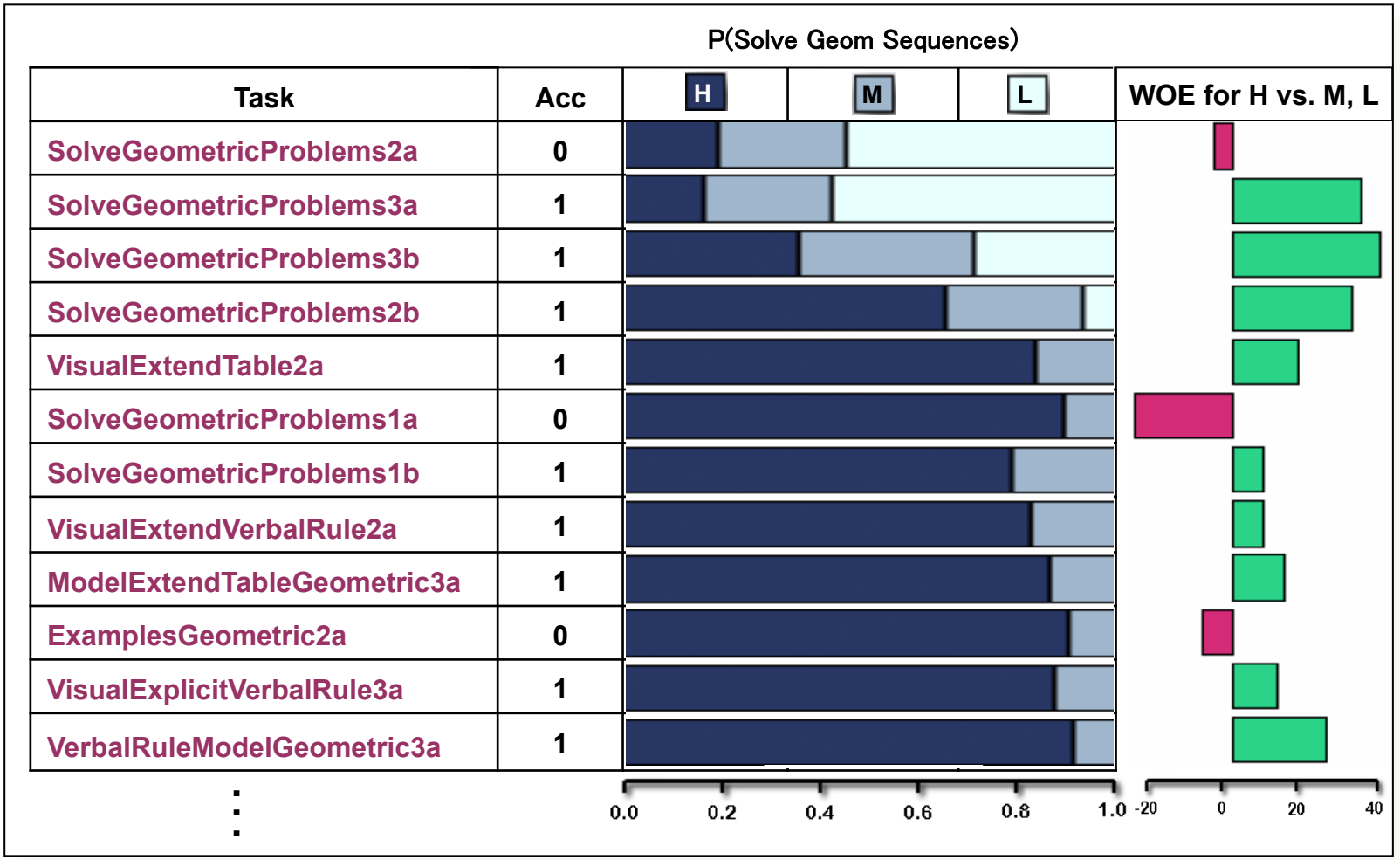
$$W(H : E_1, E_2) = W(H : E_1) + W(H : E_2|E_1)$$

- Order sensitive
- WOE Balance Sheet (Madigan, Mosurski & Almond, 1997)

Evidence Balance Sheet

63 tasks total

1 Easy
2 Medium
3 Hard
a Item type
b Isomorph



Weight of Evidence Balance Sheet

```
## Now examine scoring history
head(Student.History)
woeBal(Student.History,c("High","Medium"),"Low",
       title=paste("Evidence Balance Sheet for ",
       rownames(miniACED.data)[Student.row]))

## More ways to display scores
help(CPTtools)
```