Wed, Sep 30

Lecture 3B:
Shell scripts

Practical Bioinformatics (Biol 4220)
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Lecture 3B outline

1. Using scripts
2. Script anatomy
3. Writing scripts

Shell scripts

A ***shell script*** is a file that contains a sequence of commands that can be executed by the Unix shell

```
1 #!/bin/bash
2 # store first argument into VAR
3 VAR=$1
4 # print VAR, with too much enthusiasm
5 echo $VAR!! | tr "[:lower:]" "[:upper:]"
```

shell script, *yell.sh*

```
$ ./yell.sh 'Hello, world'
HELLO, WORLD!!
```

calling *yell.sh*

When you should write or use a script?

Scripts are useful for tasks that

- need to be ***reproduced*** by others (*or yourself!*)
- are ***complex*** and/or ***repetitious***
- are sensitive to ***user error*** (*e.g. typos*)
- rely heavily upon ***programming constructs***, like variables, if-statements, for-loops, etc.
- adhere to ***standard file formats***

Scripts vs. command line

Unix commands generally behave the same way, whether executed through the command line or through a script

Like the command line, scripts are executed:
(1) line-by-line, (2) top-to-bottom, (3) left-to-right

Complex problems often require programming constructs (*if-statements, for-loops*): easier to organize complex logic through a script

Anatomy of shell script

Hashbang (#!) designates which shell program should interpret script

Create variables $FILE1 and $FILE2 initialized by arguments $1 and $2

Text after comment (#) is ignored

Run *echo*, *cp*, *rm* commands using variables $FILE1 and $FILE2

```
1  #!/bin/sh
2
3  # set arguments to local variables
4  FILE1=$1
5  FILE2=$2
6
7  # run commands against FILE1 and FILE2
8  echo "received \'${FILE1}\' and \'${FILE2}\' as input"
9  cp ${FILE1} ${FILE2}"_copy.txt"
10 rm ${FILE1}
```

contents of *my_script.sh*

Executing a script

Scripts are run much like programs are run; some scripts are written to accept arguments and/or options

```
# call script
$ ./my_script.sh
$ sh my_script.sh

# call script with arguments
$ ./my_script.sh file1.txt file2.txt

# call script with arguments and options
$ ./my_script.sh --verbose file1.txt

# redirect script output to file
$ ./my_script.sh file1.txt file2.txt > output.txt

# use script in pipeline
$ find dir1 | ./my_script.sh file1.txt file2.txt > output.txt
```

Set file as executable

Permission must be granted to execute a file

Add 'x' to permission bitset

```
# file lacks execute permissions
$ ./process_files.sh
-bash: ./process_files.sh: Permission denied

# check file permissions
$ ls -lart process_files.sh
-rw-r--r--   1 mlandis  staff      0 Sep 20 22:06 process_files.sh

# add execute permissions (+x) to script
$ chmod +x process_files.sh

# we now see +x permissions for script
$ ls -lart process_files.sh
-rwxr-xr-x  1 mlandis  staff  0 Sep 20 22:06 test2.sh

# execute with no problems
$ ./process_files.sh
Processing files...
  ...done!
```

Variables

Variables exist in memory, and can store and report user-defined values

create $MY_DIR and $MY_FILE as ***local (shell) variables***

create new variables in terms of other variables

```
1  #!/bin/sh
2
3  # you can define your own variables
4  MY_DIR=/home/mlandis/docs
5  MY_FILE=my_file.txt
6
7  # access the value of a variable using $
8  echo "Value of MY_FILE is ${MY_FILE}"
9
10 # variables may be assigned values of other variables
11 SAME_FILE=${MY_DIR}/${MY_FILE}
12
13 # those variables can be environmental variables
14 SAME_FILE_AGAIN=${HOME}/docs/${MY_FILE}
```

$HOME is an ***environment variable***

Operators

Apply ***operators*** against numerical values to compute new values

```
 1 #!/bin/sh
 2 # =, assignment
 3 let "V0 = 6";       echo "Result for =6? $V0"
 4 # +, addition
 5 let "V1 = 1 + 2";   echo "Result for 1+2? $V1"
 6 # *, multiplication
 7 let "V2 = 2 * 3";   echo "Result for 2*3? $V2"
 8 # -, subtraction
 9 let "V3 = 5 - 4";   echo "Result for 5-4? $V3"
10 # /, division
11 let "V4 = 10 / 5"; echo "Result for 10/5? $V4"
12 # **, power
13 let "V5 = 2**10";   echo "Result for 2**10? $V5"
14 # %, modulus
15 let "V6 = 10 % 3"; echo "Result for 10%3? $V6"
```

script

```
$ ./operators.sh
Result for =6? 6
Result for 1+2? 3
Result for 2*3? 6
Result for 5-4? 1
Result for 10/5? 2
Result for 2**10? 1024
Result for 10%3? 1
```

output

if-statements

Execute code ***if*** the condition evaluates as true;
An essential tool when exact value of input is unknown!

```
1  #!/bin/sh
2
3  # modify the value of $FLAG as desired
4  FLAG=0
5
6  # evaluate condition contained in `[[ ... ]]`
7  if [[ $FLAG -eq 0 ]]
8  then
9          # if condition is true
10         echo "\$FLAG equals 0"
11 else
12         # otherwise
13         echo "\$FLAG does not equal 0"
14 fi
```

script

```
$ ./condition.sh
$FLAG equals 0
```

output

if-statement conditions

Integer comparisons

```
# is equal to
if [ "$a" -eq "$b" ]
# is not equal to
if [ "$a" -ne "$b" ]
# is greater than
if [ "$a" -gt "$b" ]
# is greater than or equal to
if [ "$a" -ge "$b" ]
# is less than
if [ "$a" -lt "$b" ]
# is less than or equal to
if [ "$a" -le "$b" ]
```

Boolean algebra

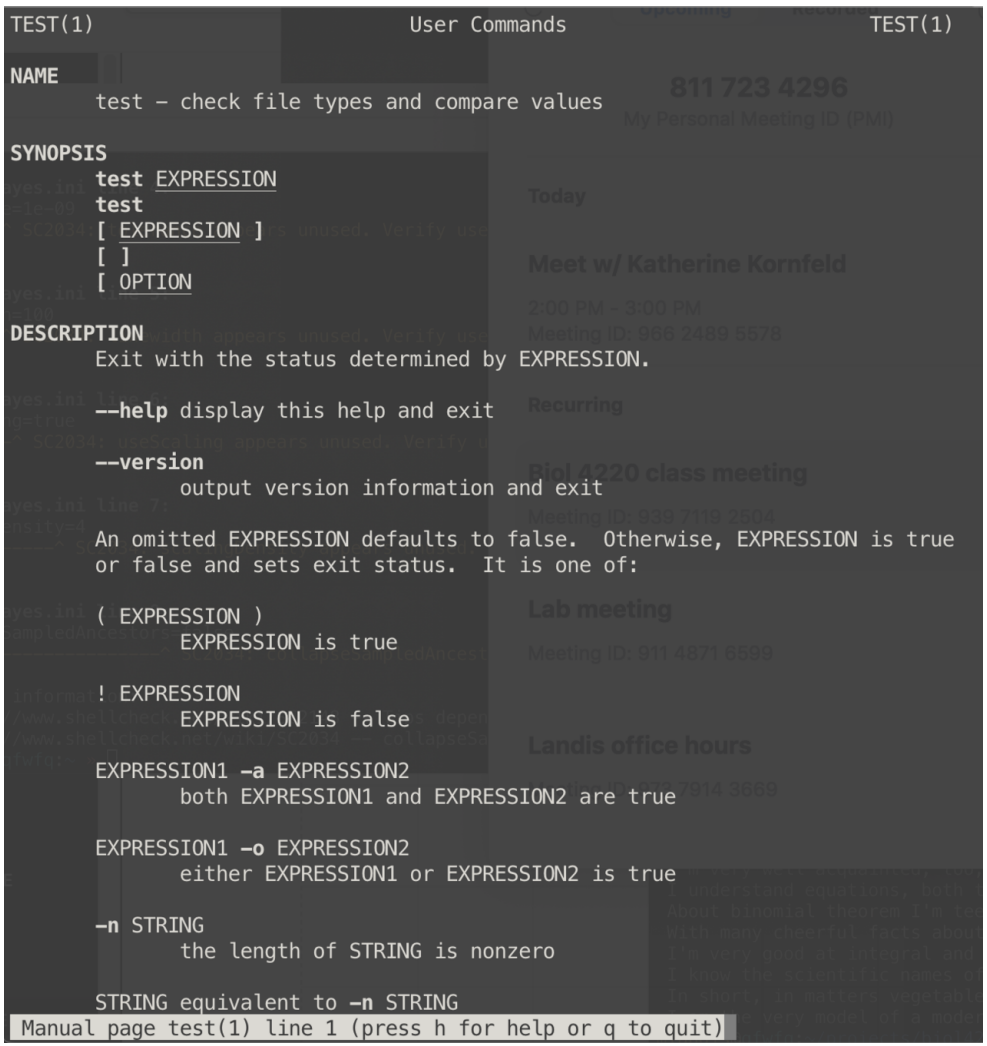
```
# NOT operator
if [ ! $a ]
# OR operator
if [ $a || $b ]
 # AND operator
if [ $a && $b ]
```

String comparisons

```
# is not equal to
if [ $a != $b ]
# is equal to
if [ $a == $b ]
# is not empty
if [ -n $a ]
```

(*only first line of if-statement shown, for brevity*)

man test, full list of conditions



```
TEST(1)                          User Commands                          TEST(1)

NAME
       test - check file types and compare values

SYNOPSIS
       test EXPRESSION
       test
       [ EXPRESSION ]
       [ ]
       [ OPTION

DESCRIPTION
       Exit with the status determined by EXPRESSION.

       --help display this help and exit

       --version
              output version information and exit

       An omitted EXPRESSION defaults to false.  Otherwise, EXPRESSION is true
       or false and sets exit status.  It is one of:

       ( EXPRESSION )
              EXPRESSION is true

       ! EXPRESSION
              EXPRESSION is false

       EXPRESSION1 -a EXPRESSION2
              both EXPRESSION1 and EXPRESSION2 are true

       EXPRESSION1 -o EXPRESSION2
              either EXPRESSION1 or EXPRESSION2 is true

       -n STRING
              the length of STRING is nonzero

       STRING equivalent to -n STRING
 Manual page test(1) line 1 (press h for help or q to quit)
```

for-loops

Apply a block of commands ***for*** each element in a set;
An essential tool for repetitious tasks!

```
1 #!/bin/sh
2 for FILE in file1.txt file2.txt
3 do
4     echo "Processing \"$FILE\""
5     cp $FILE $FILE.bak
6     echo " - backup \"$FILE.bak\" created"
7     rm $FILE
8     echo " - original \"$FILE\" removed"
9 done
```

script

```
$ ./forloop.sh
Processing "file1.txt"
 - backup "file1.txt.bak" created
 - original "file1.txt" removed
Processing "file2.txt"
 - backup "file2.txt.bak" created
 - original "file2.txt" removed
```

output

for-loop styles

General for-loop structure (*for*, *do*, *done*) does not change, but there are various ways to ***iterate*** over set-elements

```
1 for VARIABLE in file1 file2 file3
2 do
3         command1 $VARIABLE
4         command2 $VARIABLE
5         commandN
6 done
```

expanded set

```
1 for OUTPUT in $(SOME_COMMAND)
2 do
3         command1 $OUTPUT
4         command2 $OUTPUT
5         commandN
6 done
```

set as variable

```
1 N=10
2 for i in {1..$N}
3 do
4    echo "Welcome $i times"
5 done
```

set as number range

```
1 N=10
2 for (( c=1; c<=$N; c++ ))
3 do
4    echo "Welcome $c times"
5 done
```

C-style for-loop

Arguments

shell scripts store ***arguments*** into the local variables $1, $2, ...

```
#!/bin/bash
# first user argument
FILE1=$1
# second user argument
FILE2=$2
# fixed local variable
DIR1=data_170727
DIR2=data_200203
# combine arguments, local variables!,
# and environmental variables
FILEPATH1=$HOME/$DIR1/$FILE1
FILEPATH2=$HOME/$DIR2/$FILE2
# execute command
echo "Copying"
echo " - src:\"$FILEPATH1\""
echo " - dst: \"$FILEPATH2\""
cp $FILEPATH1 $FILEPATH2
echo "...done!"
```

script


```
$ ./example.sh file.txt file_copy.txt
Copying
 - src: "/home/mlandis/data_170725/file.txt"
 - dst: "/home/mlandis/data_200203/file_copy.txt"
done!
```

output

Commands

All text delimited by a pair of back-ticks (`) will be executed as ***commands***; output from any *command substitution* can be stored into local variables

```
#!/bin/bash
# where is new directory?
NEW_DIR=$1
# store current directory
CWD=`pwd`
# change directory, and get local files
cd $NEW_DIR
FILES=`ls`
# loop over files
for FILE in $FILES
do
    # sort each file
    OUTPUT=$OUTPUT`cat $FILE | sort`"\n"
done
# print sorted files
echo -e $OUTPUT
# change to original directory
cd $CWD
```

script

```
$ cat tmp/a.txt
whale
alligator
bear
$ cat tmp/b.txt
banana
watermelon
apple
$ ./example.sh tmp
alligator bear whale
apple banana watermelon
```

output

Whitespace

Shell uses whitespace to distinguish between commands, options, and arguments

```
#!/bin/bash

# valid assignment (no spaces)
VAR="my_file.txt"

# invalid assignment (extra spaces);
# shell will attempt to execute the
# program `VAR`
VAR = "my_file.txt"
```

variable assignment must not contain spaces

```
# valid if-statement (spaces)
if [ $VAR == "my_file.txt" ]
then
        echo "match!"
fi

# invalid if-statement (no spaces)
# the syntax `test` using `[]` brackets
# is `[ EXPRESSION ]` not `[EXPRESSION]`;
# shell will not recognize the
# `[$VAR` command
if [$VAR == "my_file.txt"]
then
        echo "match!"
fi
```

if-statement brackets must be separated from the condition by spaces

First, write pseudocode

Outline your script with commented ***pseudocode*** before populating your script with working code

```
 1 #!/bin/sh
 2
 3 # store arguments as named variables
 4
 5
 6 # loop over all files
 7
 8
 9
10
11         # if file passes test, do this
12
13
14         # if file fails test, do this
15
16
17
18 # report to user
19
20
```

Then, write code

Add code/commands to execute the tasks defined by pseudocode

```
#!/bin/sh

# store arguments as named variables
FILE1=$1
FILE2=$2
# loop over all files
for $f in $FILE1 $FILE2
do
    if [[ -z $file ]]
    then
        # if file passes test, do this
        OUTPUT=$file" not empty;"$OUTPUT
    else
        # if file fails test, do this
        OUTPUT=$file" empty;"$OUTPUT
    fi
done
# report to user
echo $OUTPUT | tr ";" "\n" | cat > output.txt
echo "task complete"
```

Lab 3B

github.com/WUSTL-Biol4220/home/labs/lab_03B.md