

Session 4

Temporal Response

Array Access

Reference Operators

Convolution

Review of last time: Cushioning, Crowding and Quantization

4/2

- Modeling is inexact, so we use safety margins
- Sometimes you plan shortages
- Sometimes resources are available only in certain minimum size lots
- Excel functions that help with these issues:
CEILING, FLOOR, INT, ROUND, TRUNC, MROUND
- Circular references
 - Arise when loops of cells depend on each other
 - Break the circularity by solving the equations if possible

Excel functions for array access

4/3

- INDEX

- INDEX(1 Dimensional Array, n) -> n^{th} item
- INDEX(2 Dimensional Array, m , n) -> n^{th} item in m^{th} row
- INDEX(2 Dimensional Array, n , 0) -> n^{th} row
- INDEX(2 Dimensional Array, 0, n) -> n^{th} column


- OFFSET

- OFFSET(reference, n , m) ->
 - A region of the same shape, displaced down n rows and right m columns
- OFFSET(reference, n , m , p , q) ->
 - A $p \times q$ region displaced down n rows and right m columns
 - If either p or q is omitted, the result is the same as if you had supplied the corresponding size of *reference*

- Colon
Same as “the minimum rectangular region including both”
 - A2:B7 means “the minimum rectangular region including both A2 and B7”
- Comma
Same as “and”. Thus A1:A2,B1:B2 is a reference to a range with two areas and four cells.
Surround with parens for safety and readability: (A1:A2,B1:B2)
- Space
Same as “intersection”
(A1:B3 B2:C3) is the intersection (B2:B3)

Surround with parens for safety and readability

- Many business process models involve time evolution
- Typical problems:
 - If you hire a new employee, their productivity is initially low, but develops over time
 - When you introduce a new product, you often have an associated short-term training burden that declines over time in your installed base
 - When you first initiate service to a new client, snags and confusion may be common, but eventually things clear up
- How do you conveniently model time-varying processes in a time-varying environment?
 - Use analysis — first model the “base response” to a simple input
 - Use synthesis — find total response to a sequence of delayed simple inputs
- This summing of base responses is easy with macros

- Convolution is an operation on two data streams
 - One stream is the *base response* — the response to a “basic input”
 - The other is the sequence of inputs
- Example: Productivity of a new hire  Convolution Graphically
 - When you hire someone
 - The “base response” or “response to a basic input” is their contribution to overall production
 - The “basic input” is the hiring of one person
 - To find the productivity of a stream of hires, you convolve the base response (productivity of a single hire) with the sequence of inputs (hiring schedule)

When can you use convolution? 4/7

- The “response” must be time-invariant
 - Its shape and size must be independent of the time when you apply the input, other than a delay
 - Delaying a hire just delays the contribution of productivity by the amount of the delay, but doesn’t change its size or shape
- The response must be linear
 - Size of the response must be proportional to the size of the input
 - If I double the number of hires, the “productivity response” should double
- The system must be non-predictive
 - The system does not respond to an input until the input arrives
- These criteria are needed because we are using Analysis/Synthesis
 - Analysis — break the “input” into a sequence of delayed “basic inputs”
 - Synthesis — assume that responses to different inputs just add up

Approaches to modeling temporal response

4/8

- Two approaches to implementing convolution
 - Construct a table, one line for each unit delay
Two approaches:
 - Hard-wired explicit cell references
 - Computed references
 - Use a macro (called “Convolve”)
 - You don’t have to write it, it is provided
- Comparisons of the macro and table approaches:
 - Macro is slower to execute
 - Macro is easier to use
 - Tables use more memory and screen area
 - Tables are more difficult to maintain

- Model the productivity of new employees over a ten-week period
 - Two weeks of classroom and laboratory training
 - Three weeks of 80% productivity
 - 100% productivity thereafter
- Model the load on trainers per new employee
 - 20% for two weeks
 - 5% for the next three weeks



- To do the homework you'll need to install the Convolve macro as an Excel add-in on your computer
- Please do not copy the Convolve macro into your homework workbooks
 - Homework workbooks that contain macros are not accepted
 - This is a virus safety policy
- For your own personal use, you might want to include Convolve in workbooks
 - Some people who use your work might not have Convolve
 - Some computers you use might not have Convolve

Add-ins, versions, & collaboration

4/11

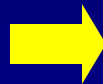
- When you collaborate with others, you want to swap workbooks
- If you use worksheet functions from add-ins, and your versions differ:
 - The add-in filenames can be different for different versions
 - When they differ, you get an “external link” notification upon loading
- To fix this relink the workbook from your partner’s add-in to yours
- Excel has a (somewhat cumbersome) way to do this
 - It warns you upon loading, or
 - Data>Edit Links (Excel 2007-10) or Edit>Links... (Excel 2003-4, 2011)
- We provide a convenient way to do this for our add-in:
Change SMM Link



- Excel Technology
 - Learn to use the worksheet functions INDEX and OFFSET
 - Learn about the reference operators (comma, space, colon)
- Convolution is an operation that takes two arguments
 - The response to a unit basic input
 - A stream of inputs at various times
- The result is the sum of the responses to the various components of the stream of inputs
 - We assume that we can delay the basic input, and that just delays the response by a like amount
 - We assume that we can just add up the delayed responses to the delayed components of the inputs
- Convolution is easy if you use a macro to compute it

- Arrays and Array Formulas
- Worksheet Functions
 - INDEX
 - OFFSET
- References
 - Relative vs Absolute
 - External and Internal
 - A1 and R1C1 style
 - Reference operators

Read sections of Excel on line help or



Readings: Worksheet Functions
Readings: References
Readings: Reference Operators
Readings: Windows and Macintosh Compared
Readings: Workbooks
Readings: Array Arithmetic
Readings: Convolution

Preview of next time: Course Project Proposals

4/14

- Course project requirements
 - Gathering and understanding requirements are important parts of your project
 - Examples of requirements
 - How to gather requirements systematically
- Course project proposals
- How to merge workbooks