Unreal Course Section 2 Slides

<< To Section 1 To Section 3 >>

These are the slides that accompany the Complete Unreal Developer Course.

See me develop the slides as I write the course…

- Right click or Insert > Comment to comment, especially if you see a typo
- A PDF version will be attached inside the Unreal course.
- The slides will update immediately as I change things.

Enjoy your stay!

Ben Tristem

Intro, Notes & Assets

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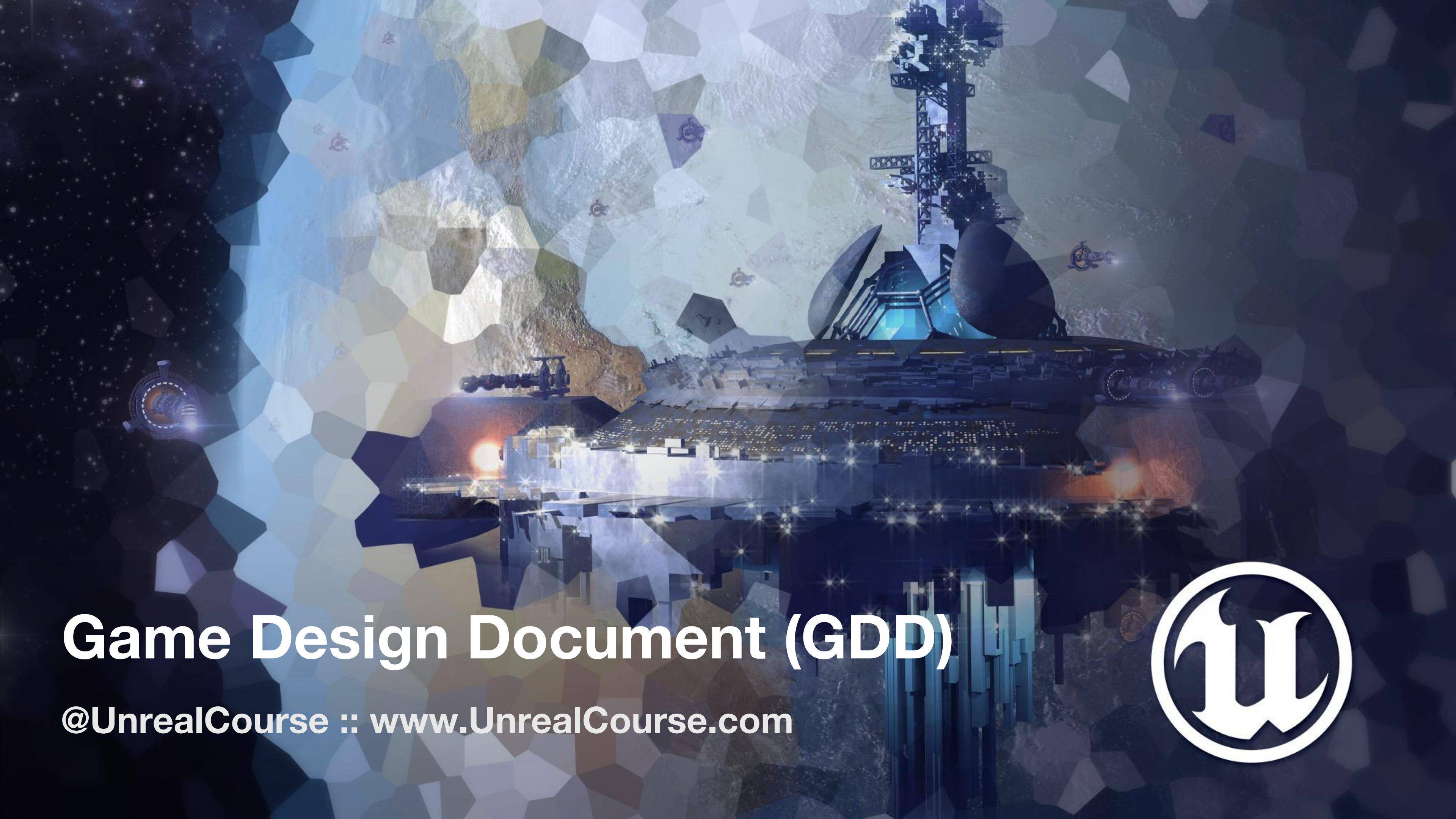
In This Video...

- Welcome to the first actual coding video.
- Why we’re doing this in the IDE only.
- What you’ll be building, see resources.
- You’ll learn types, loops, routines, classes.
- We’ll follow Unreal’s coding style, and re-use.
- Notes and resources are attached.



Game Design Document (GDD)

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In This Video...

- How much planning should we do?
- Define the emotional **problem** the game solves*
- Chose concept, rules & **requirements**.
- Start to think about the **architecture**.
- *Copy* as much as possible into the code!
- Document now what may change later.

* McConnell, Steve. *Code Complete.* Microsoft Press 2004. Chapter 3.3

The Problem

- I want a mental challenge.
- I want to feel smart / prove myself.
- I miss word puzzles.
- I want to prove myself.
- I want to challenge (feel superior to) someone!
- Etc

Concept & Rules

- This is a “guess the isogram” game.
- An isogram is a word with no repeating letters.
- The user has a limited number of guesses.
- After each guess the computer outputs…
    - Bull = right letter in the right place.
    - Cow = right letter in the wrong place.
- You win by guessing the word within max tries.

Write Up The Requirements

- What will the **inputs** be? In what format?
- What will the **outputs** be?
- What **tasks** will the user be asked to do?
- Any **performance** limits worth mentioning?
- What **assets** (art, sound, story text) do we need?

Requirements

- Plain text instructions for all interactions.
- Code to help the player make a valid guess (e.g. all lowercase, an isogram, right length).
- Code to check the number of Bulls and Cows in the guess, compared the hidden word.
- Code to keep track of the number of valid guesses.

Possible Future Ideas (The NO List)

- Give feedback on every key press.
- Have a large dictionary of hidden words.
- User selectable word length, and difficulty.
- Checking the user’s guess is a dictionary isogram.
- Providing a time limit for the guesses.
- A hint system, spend a turn for a hint.

How Solutions & Projects Relate

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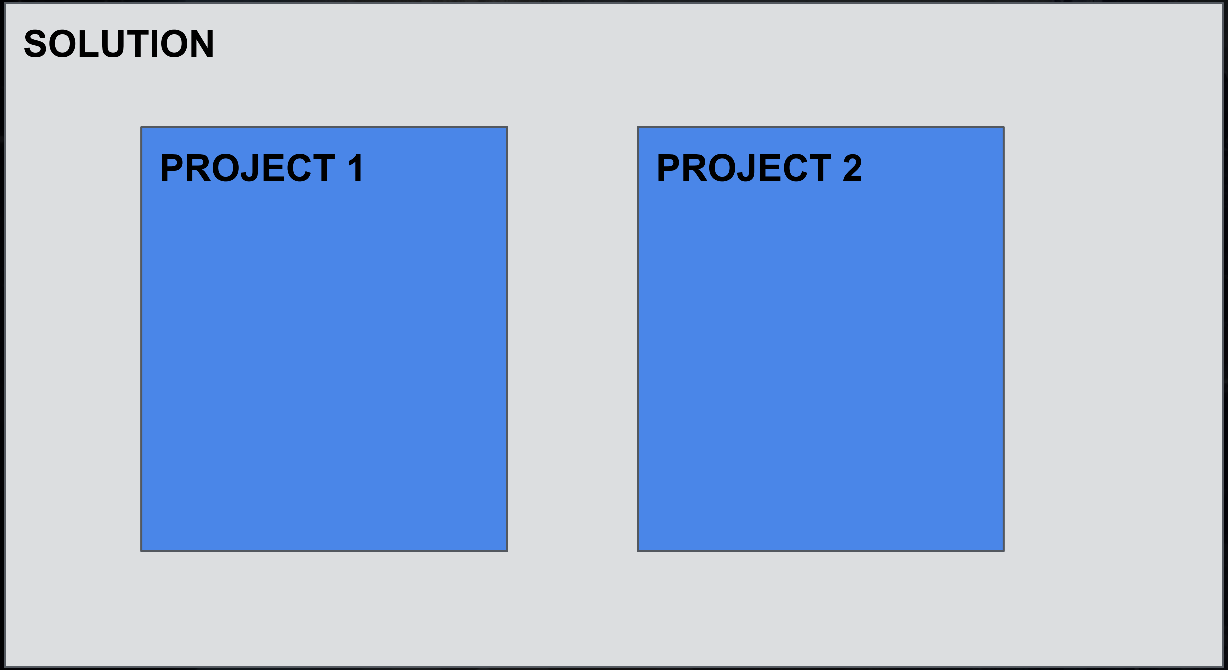
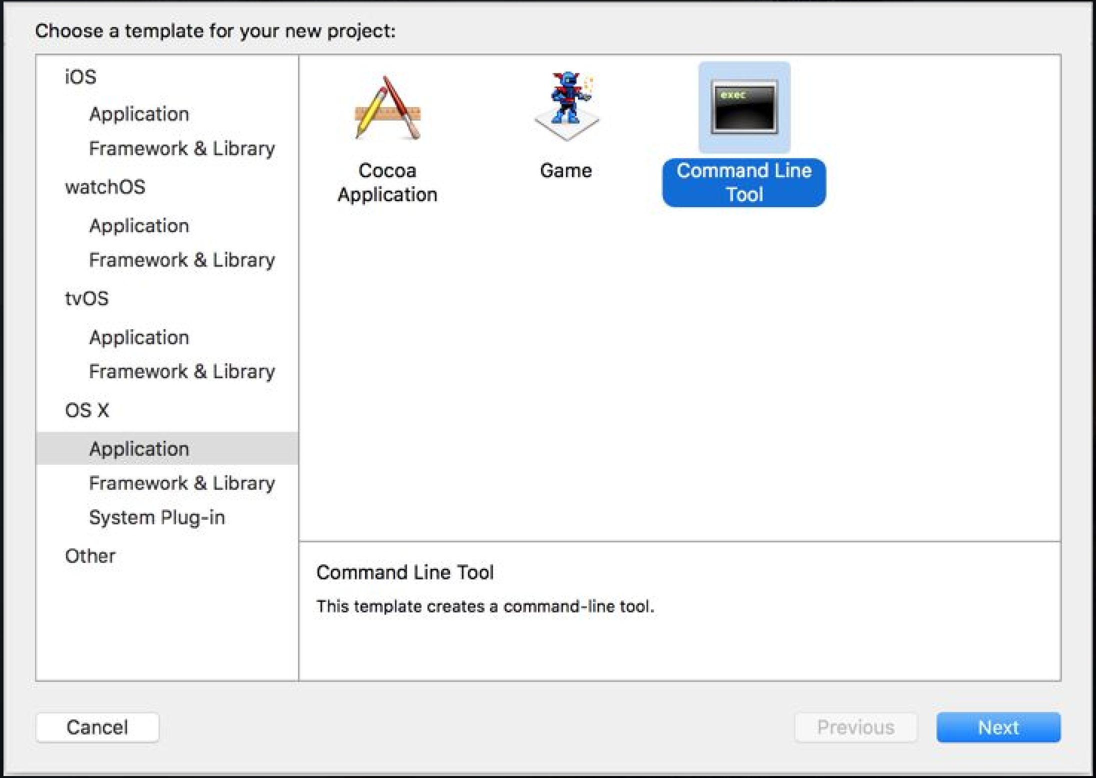
In This Video...

- How projects and solutions relate.
- Setting up a new command line project.
- An overview of the structure of our solution.
- (Adding `main.cpp` to our project).

How Projects & Solutions Relate



Creating the project in Xcode



Command Line Tool

This template creates a command-line tool.

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Setup Your Project

You want to end up with…

- **UnrealCourse > Section_02** <= section / solution
- **Section_02 > BullCowGame** <= project folder
- **BullCowGame > BullCowGame.vcxproj**
- **BullCowGame > main.cpp**

C++ Function Syntax

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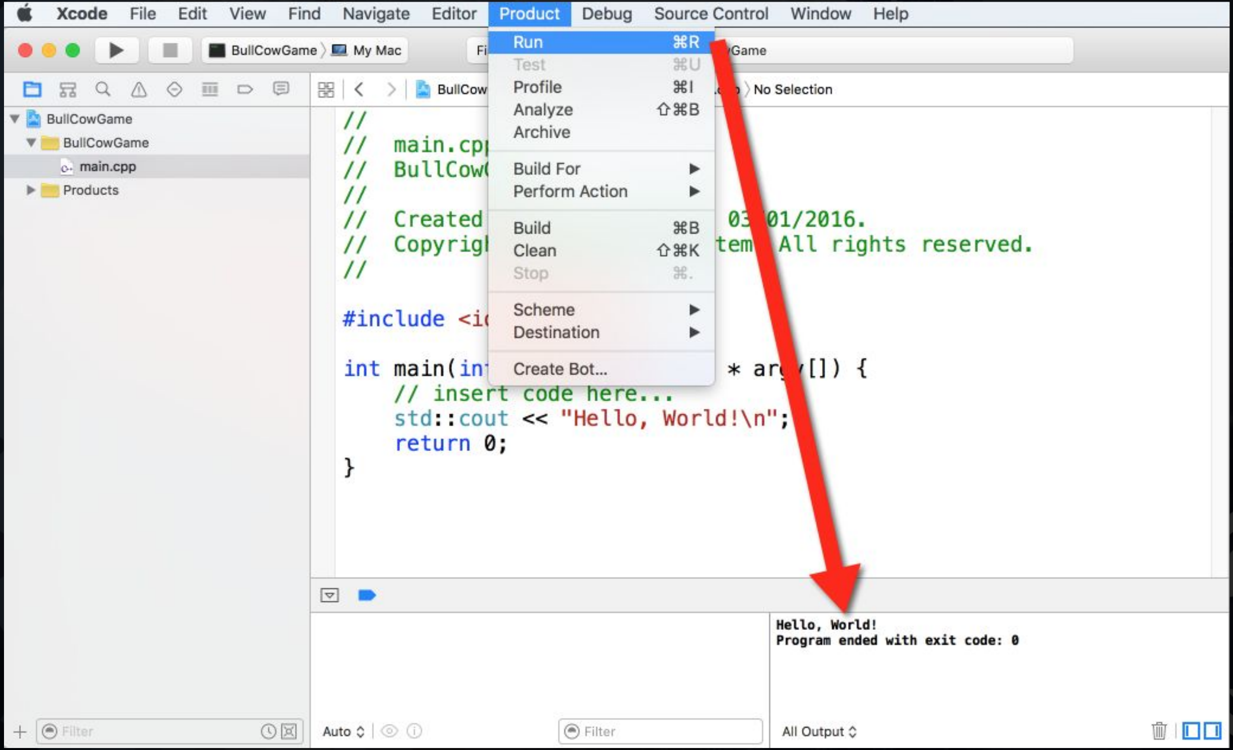
In This Video...

- The difference between an engine and a library.
- How this relates to this console application.
- What is building / compiling code?
- How the console knows where to find our code.
- The syntax of a function in C++.
- Write the minimal C++ program to remove error.
- Testing our application runs without error.

Building (running) in Xcode



```
//
//  main.cpp
//  BullCow
//
//  Created                03/01/2016.
//  Copyrig            tem  All rights reserved.
//

#include <i

int main(in                 * ar  []) {
    // insert code here...
    std::cout << "Hello, World!\n";
    return 0;
}
```

```
Hello, World!
Program ended with exit code: 0
```

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The syntax of a function in C++

```
int DoubleMe(int number)
{
   return number*2;
}

<return_type> <name> (<parameters>)
{
   <statements>
}
```

Write the minimal C++ program

- Return type is `int` (short for integer).
- Function name is `main` (lowercase m).
- Takes no parameters.
- Extra credit: make it return 0.
- Test by running and see if the error goes away.

Using, `#include` and Namespaces

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In This Video...

- # represents a “preprocessor directive”.
- `#include` copies-and-pastes other code.
- The idea of using library code.
- Use <> for standard libraries.
- Use “ “ for files you have created yourself.
- Notice the namespace icon in autocomplete.
- Import `iostream` library and use `std` namespace.

Using cout vs printf()

- There are pros and cons.
- You’ll see both in other people’s code.
- Read more at the link below.

http://stackoverflow.com/questions/2872543/printf-vs-cout-in-c

Use the `std` namespace

- Make appropriate use of the using statement.
- Test by removing `std::` prefix from your `cout`.
- Explain the risk in the discussions.

Magic Numbers and Constants

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In This Video...

- What a “magic number” is.
- Why it’s a good idea to avoid them.
- `constexpr` means “evaluated at compile time”.
- Introduce coding standards*.
- Use a constant for the word length.

*https://docs.unrealengine.com/latest/INT/Programming/Development/CodingStandard/index.html

Include word length in intro

- Include the WORD_LENGTH in the intro text.
- Make sure it prints with spaces properly.

Variables and `cin` for Input

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In This Video...

- The difference between `\n` and `endl`
- Introducing pseudocode programming
- Why we need to `#import <string>`
- Getting input using `cin`
- Discovering woes with our input buffer.

Take and repeat back the guess

- Ask the user for their guess.
- Use `cin` to take guess on the same line.
- On the next line, repeat back the guess.

Using `getline()`

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In This Video...

- Re-cap the problem we have.
- Why `getline()` is useful here.
- Where to find C++ documentation.
- A word on non-obvious solutions.

Why `getline()` is useful here

- It will read through any spaces by default.
- It will discard the input stream once it reaches the new-line character.
- Read about it by searching for getline at www.cplusplus.com.
- Find out about this sort of thing by

Fix the input problem

- Replace both `cin` lines.
- Test that donkey kong is accepted as a guess.

Simplifying With Functions

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In This Video...

- Programming is all about managing complexity.
- We want to think about a few things at a time.
- The idea of abstraction and encapsulation.
- How functions help us simplify.
- Write and call your first functions.
- A warning about “side-effects” of functions.
- Always use `return` at the end of your functions.

Abstraction and encapsulation

- A major goal in writing software is to manage complexity.
- **Abstraction** is a technique for managing complexity, by considering things at a higher level.
- **Encapsulation** is a way of making sure your abstractions are adhered to.

`return` in a `void` functions - pros

- Makes you think about where you leave the function.
- It's consistent with code Visual Studio creates for you.
- You can return earlier than the end (for example an error check fails).

`return` in a `void` functions - cons

- It's extra code, and less code is generally better.
- Somebody may write statements below it later, which never get executed.

Write `string GetGuess()`

- Save your code so you can go back.
- Write a function to get the `Guess`
- `return` it as a string.
- Restore your code to its former working glory.

Iterating With For & While Loops

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In This Video...

- Why we need loops.
- When to use `for` vs `while`.
- The syntax of a `for` loop.
- Think carefully about the first & last loop.
- Write a `for` loop to repeat the game.

When to use `for` vs `while`

- Pick a standard to keep yourself sane, e.g.

- **“Know what you’re in `for`”** - you know at compile time how many times it will loop.
- **“May be looping for a `while`”** - you’re not sure how many times it will loop.

The syntax of a for loop

```
for (initialization; condition; increase)
    statement;

for (int count = 1; count <= limit; count++)
{
    <the code you want to repeat>
}
```

http://www.cplusplus.com/doc/tutorial/control
https://msdn.microsoft.com/en-us/library/b80153d8.aspx

Make the game take 5 guesses

- Use what you've learnt so far to make the game take 5 guesses in a row.
- GetGuess() should appear as a function call only once inside a `for` loop.
- Bonus: remember what I said about magic numbers.

Clarity is Worth Fighting For

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In This Video...

- More about levels of abstraction.
- A word on being clever.
- Using Visual Studio’s Extract “Extract Function”
- What a header file (.h) is.
- What’s refactoring, and why we do it.
- Removing side-effects.
- Where to find the course code on GitHub.

An aviation quote...

“Truly superior pilots are those who use their superior judgment to avoid those situations where they might have to use their superior skills.”

Remove the side-effect

- Rename the `GetGuessAndPrintBack()`.
- Move the offending code.
- Test it all still works.
- Are you very happy with how your code reads?

booleans and comparisons

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In This Video...

- What a `bool`ean is, and how to use it.
- Only use when completely clear what you mean.
- Use `==` for comparison.
- Use `&&` for logical AND.
- Use `||` for logical OR.
- Use `[n]` to access a string, starting at n=0.
- Use ‘ ‘ for characters, and “ “ for strings.

Write rest of `AskToPlayAgain()`

- Allow for ‘y’ or ‘Y’ as the first letter.
- You can ignore the rest of the letters.
- Return true for for yes, false for no*

* This is on the limit of what’s “obvious”.

Using `do` and `while` in C++

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In This Video...

- What a `do while` loop is.
- How it executes code one or more times.
- Making our game play multiple times.

The syntax of a `do while` loop

```
do {
    <the code you want to repeat>
}
while (condition);
```

The code gets executed once before the check.

http://www.cplusplus.com/doc/tutorial/control
https://msdn.microsoft.com/en-us/library/b0kk5few.aspx

Make the game play multiple times

- Put a `do while` loop in main.
- Refer to example on previous slide for syntax.
- Test you can play as many times as you like.

Introducing Classes

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In This Video...

- Lookup the Turing machine.
- A quick overview of the MVC pattern.
- User defined types (classes).
- About working at an interface level (black box).
- An overview of `class FBullCowGame`

Read around the topic

Read around these topics…

- Model View Controller (MVC) pattern.
- Turing machines (e.g. Computerphile on YouTube).

Using Header Files as Contracts

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In This Video...

- Introducing .h header files in C++.
- Why the added complexity is worth it.
- Defining the interface to our class.
- Writing our first draft of `FBullCowGame.h`

Write all the methods you can

- Write as many simple signatures as you can
- Don’t worry about getting it “right”
- There is no right anyway, the point is to think
- Enjoy working at a higher level.

Including Our Own Header File

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In This Video...

- NEVER use using namespace in a .h
- In fact, why use it at all?
- Create your .cpp files and `#include`
- Don't create chains of includes.

Finish writing blank definitions

- Write blank definitions for all methods.
- Ensure there are no warnings in the .h file.

Instantiating Your Class

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In This Video...

- Relax, they're just user defined types!
- `string FirstName;` creates a string object
- `FBullCowGame BCGame;` works the same way
- These instances are initialised by "constructors"
- Instantiating means "creating an instance of"
- So we're simply creating a game instance.

Create a `BCGame` instance

- Make it the first line of `PlayGame()` for now
- Declare a new object called `BCGame`
- Make its type `FBullCowGame`
- Don’t worry about “initialising” it yet
- Make sure you code still runs.

Writing & Using Getter Methods

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In This Video...

- What is a getter method
- Why we never access variables directly
- How to call a method using the dot operator
- Pros and cons of initialising in at compile time
- Using “Rebuild Project” to make VS behave!

Implement `GetCurrentTry()`

- Initialise the value to 1 in the header file (for now)
- Check it works by printing the try from GetGuess()
- For example: "**Try 1.** Enter your guess: "
- where 1 is the value of MyCurrentTry.

Introducing the `const` Keyword

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In This Video...

- `const`'s meaning depends on context
- Generally means "I promise not to change this"
- What this is depends on exactly where it appears
- At the end of a member function, for example `int GetCurrentTry() const;` it prevents the function from modifying any member variables
- This is a good safety feature.

Apply `const` to all your getters

- Make all getter methods const
- Check it still runs
- Are any of the other functions we've written so far candidates for the use of `const`? If so please suggest which (if any) in the discussions.

Constructors For Initialisation

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In This Video...

- Default constructor called when object created
- Initialize in constructor when decided at runtime
- Initialize in declaration if known at compile time
- Constructor syntax simply: `ClassName();`
- Set the member variables in constructor
- Test this has worked.

Write and test `Reset()`

- Initialise all the member variables
- Set the max tries to 8
- Use the appropriate constant for the magic #
- Check that it works by using `cout` as needed.

Pseudocode Programming

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In This Video...

- More on Pseudocode Programming Practice (PPP)
- Reviewing our code and architecture
- Using `// TODO` as a comment prefix
- Introducing Visual Studio’s Task List
- Planning our next wave of coding.

Write your own notes and TODOs

- Go through your code, make sure it makes sense
- Action any existing TODOs that you can
- Write any new TODOs for tasks that must be done
- Do NOT use code in these comments
- Give yourself the gift of working at a higher level.

Using `using` for Type Aliases

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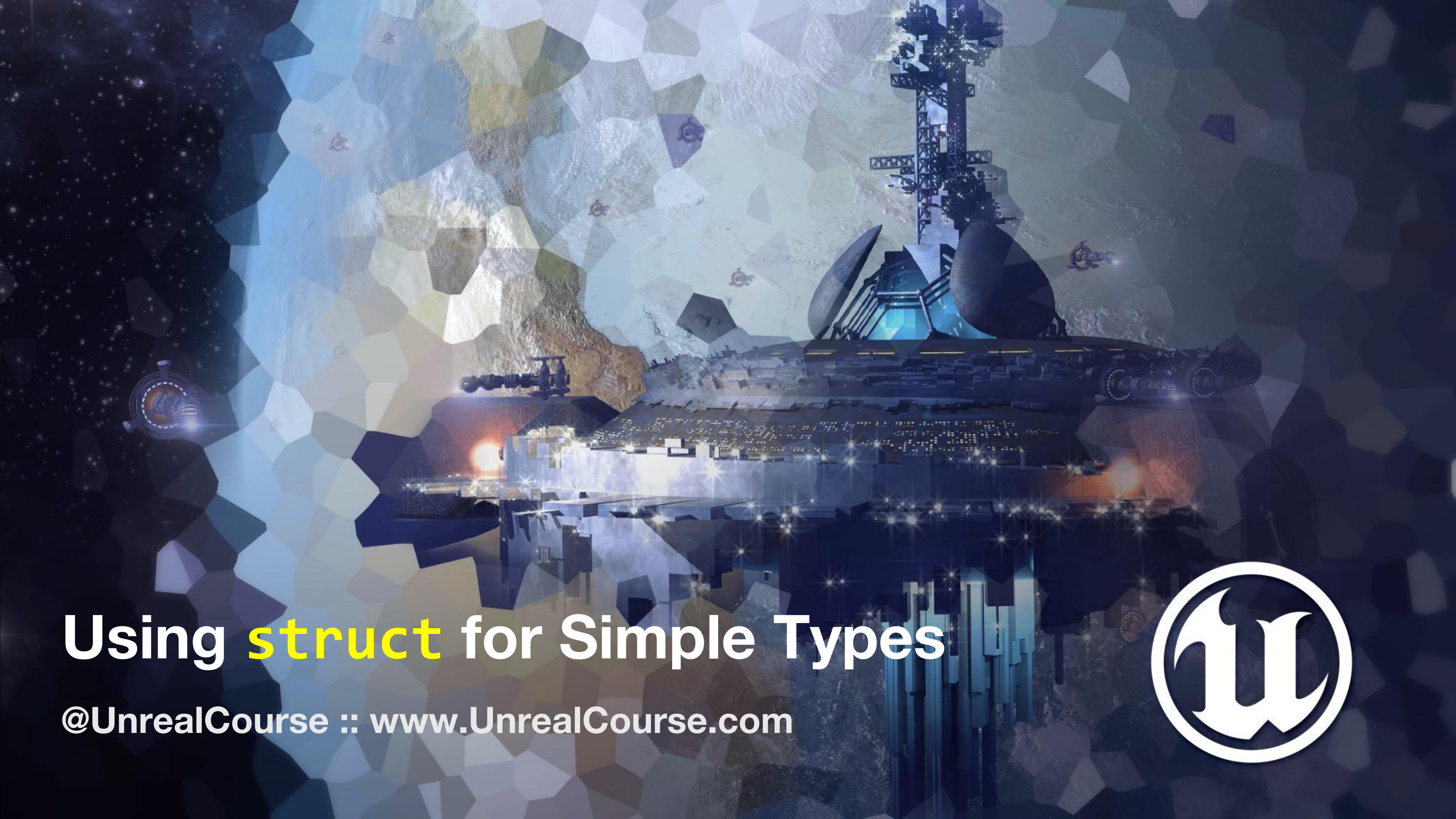
In This Video...

- We’re substituting types to be “Unreal ready”
- The declaration is `using <alias> = <type>;`
- For example `using int32 = int;`
- Why Unreal uses `int32` rather than `int`
- `FText` is for output, `FString` is “mutable”
- Where to use each type of string
- Map `FText` and `FString` to `std::string`

Substitute the integer type

- Convert all integers to use the `int32` alias
- Exclude `int main()` as this is called by the OS
- Explicitly substitute at top of file, not via include
- Test your code still runs and reads well.



Using `struct` for Simple Types

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In This Video...

- `struct` is almost identical to `class`
- It’s member variables (data) is public by default
- Ideal for simple value types like `BullCowCount`
- Outline `BullCowCount SubmitGuess(FString)`

Pseudocode the function

- Write out the “algorithm” for the function.
- Make your best effort.
- Avoid the use of any code.
- Indent comments inside any loops.

Using `if` Statements in C++

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In This Video...

- Why we need conditionals (selection)
- Use `if` when it reads better (e.g. few conditions)
- Use `switch` for multiple, simple conditions
- (for loads of statements consider a table lookup)
- The syntax of an `if` statement
- Using `if` to write count bulls and cows.

if syntax

```
if (condition1) {
    statements;
} else if (condition2) {
    statements;
} else {
    statements;
}
```

Note this is slightly more compact than Unreal’s coding standards.

Finish `SubmitGuess()` and test

- Finish the function
- Test it works as expected
- Celebrate your coding ninja skills.

Debugging 101

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In This Video...

- A very brief intro to Visual Studio’s debugger
- Set a break-point by clicking in margin
- Watch values by highlighting in debug mode
- Use “Continue” to cycle back to breakpoint.

Squash the bug

- Fix the bug
- That’s it.

A Place for Everything

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In This Video...

- Centralising the hidden word length
- Making this a property of the game class
- Writing a getter to access this value
- Updating our intro to vary with word length.

A Place for Everything

- “A place for everything, everything in it’s place”
- Think carefully about what you store
- General bandwidth vs. storage
- Another example CPU vs. RAM
- For example store birthday not age
- Until proven otherwise, don’t store results*

http://gameprogrammingpatterns.com/data-locality.html

Replace `WORD_LENTGH`

- Write `GetHiddenWordLength()` getter
- Make it read from the current word length
- Do not create another member variable
- Replace `WORD_LENGTH` in `PrintIntro()`
- Test with different hidden word lengths.

Introducing enumerations

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In This Video...

- An `enum`erated type consists of named values
- Use instead of coded meaning
- Makes the code more readable and meaningful
- Only defined values can be used - more robust
- A benefit of C++ 11's strongly typed enums
- Creating an `enum class` for error checking.

Finish the error value list

- Write at least two more error values
- Think about what could break the game
- … or try weird input and see what DOES break

Writing Error Checking Code

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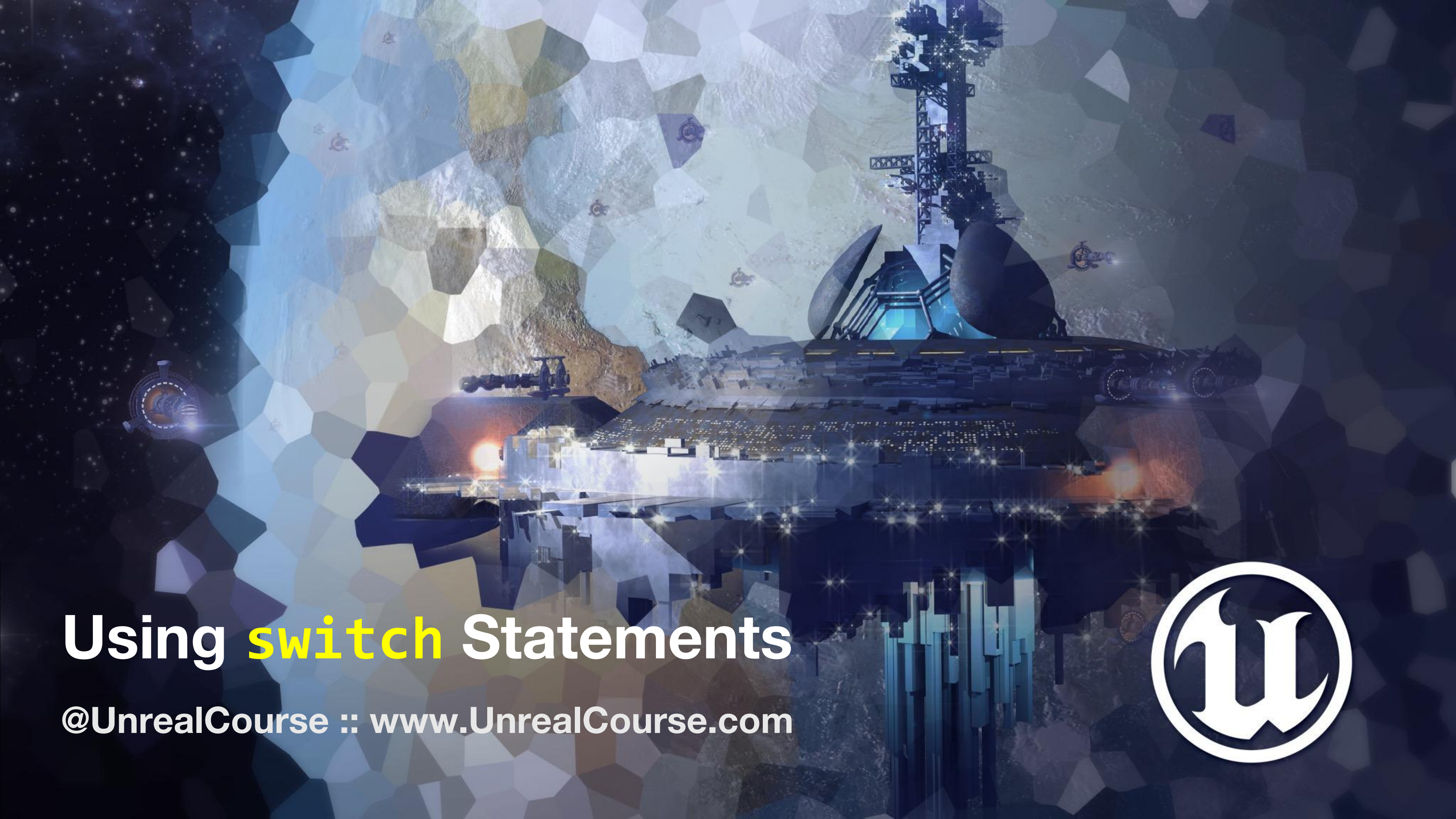
In This Video...

- Use `else if` for the first time
- Outline or `CheckGuessValidity()` method
- Write working code for checking guess length
- Use the debugger to test the return values.

Write the word length check

- No need to call any “helper methods”
- Use != for “not equals”
- Call `GetHiddenWordLength()`
- Test the value using the debugger.



Using switch Statements

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In This Video...

- Use our error values to communicate with user
- All our user interaction is via `GameManager.cpp`
- We'll use `FText` in this file, as it's UI text
- We can "switch" what we say based on the error
- The syntax of a `switch` statement
- Remember your `break` keywords!

switch statement syntax

```
switch (expression)  // expression is what we switch based on
{
  case constant1:
     statement(s);
     break;
  case constant2:
     statement(s);
     break;
  default:
     statement(s);
}
```

Write the rest of the errors

- Write a message to the user for each error
- Tell them how to get it right next time
- Remember your `break` statements!
- Test the console output for wrong word length.

Warm Fuzzy Feelings

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In This Video...

- *Don't* get comfortable with compiler warnings
- Refactor `GetValidGuess()` to remove warning
- Rename `SubmitGuess()` to `SubmitValidGuess()`
- Improve readability of `SubmitValidGuess()`
- Get a warm fuzzy feeling!

Try and remove the warning

- Try and remove the warning
- Check your code still runs
- Watch my suggested method.

Handling Game Win Condition

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In This Video...

- Change our `PlayGame()` loop to a `while`
- Implement our `IsGameWon()` function

Finish `IsGameWon()`

- Define the appropriate getter method
- Create a private variable, prefixed with b
- Set the private variable in `SubmitValidGuess()`
- Test you can now win the game.

Win or Lose "Screen"

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In This Video...

- Write a method to print a game summary to the screen once the game is over.

Define `PrintGameSummary()`

- Arrange for a “You won / bad luck” message
- Decide where in the program it goes
- Write a function for it
- Test it works.

Introducing Big O Notation

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In This Video...

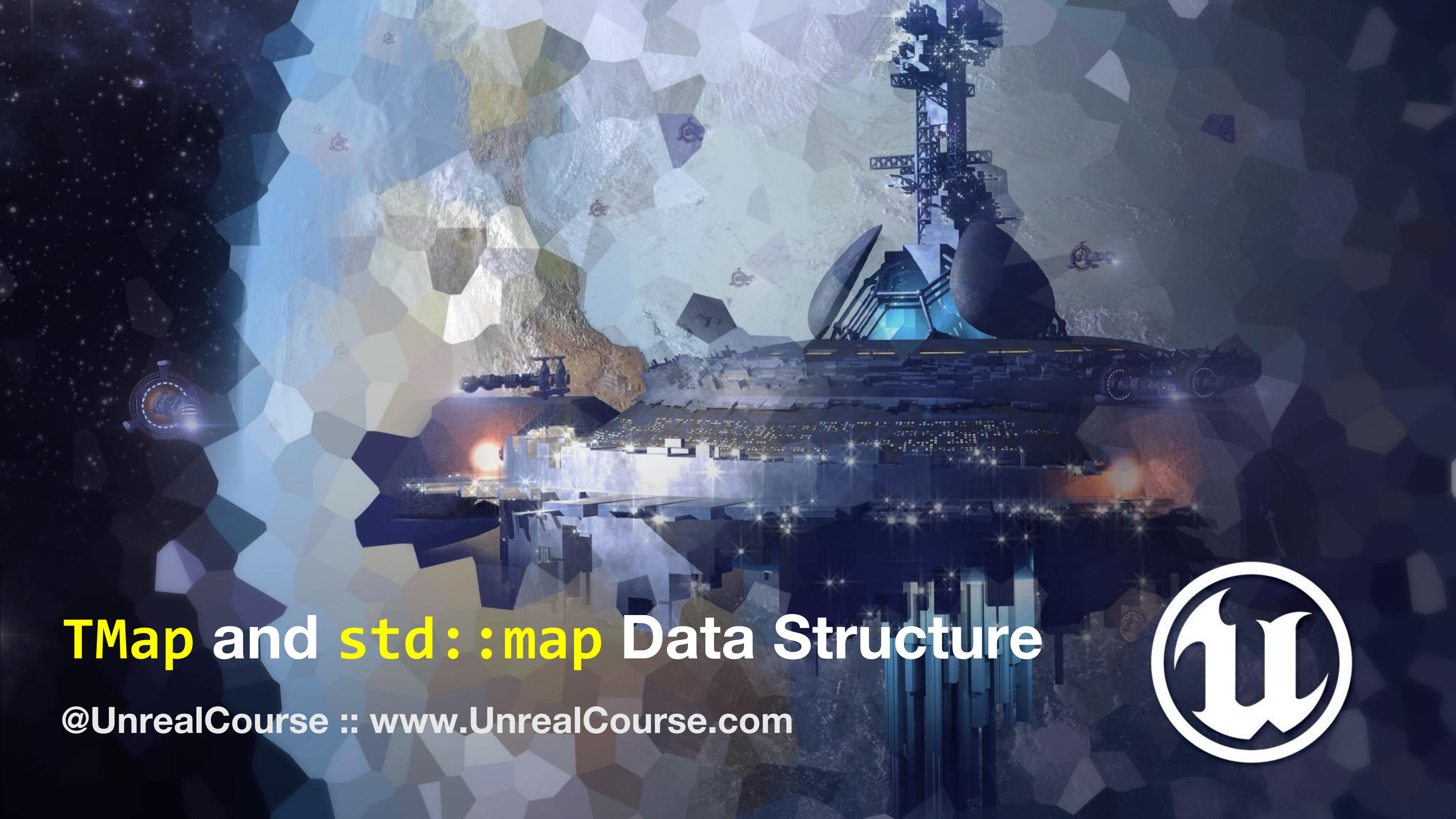
- Algorithm: the recipe for solving a problem
- or: 45th US Vice President’s dance style
- Introducing the complexity of algorithms
- A quick introduction to “Big O” notation
- Comparing three ways of checking for isograms.

What order is `IsIsogram()` at best?

- Vote for O(n), O(n log n) or O(n^2)
- Share your vote in the discussions
- Explain why you think that’s as fast as possible
- Carry on watching.

Further reading

- http://stackoverflow.com/questions/9107516/sorting-characters-of-a-c-string
- http://en.cppreference.com/w/cpp/algorithm/sort
- http://www.wolframalpha.com/input/?i=n%5E2+vs+%28n+log+n%29+vs+n%2C+n%3D2+to+17
- https://en.wikipedia.org/wiki/Sorting_algorithm
- https://en.wikipedia.org/wiki/Big_O_notation
- https://en.wikipedia.org/wiki/Isogram



TMap and std::map Data Structure

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In This Video...

- The importance of knowing your data types
- Introducing the `std::map` data type
- `#define TMap std::map` to keep it ‘Unreal’
- How we’ll be using the map
- Wiring-up and pseudocoding `IsIsogram().`

How we’re using a map...

Using the word hApPy as an example...

Key	Value	Note
h	true	
a (translated from A)	true	
p	true	
p (translated from P)	true	`return false;`

“Wire-up” IsIsogram()

- Create a private *function*
- Decide if it should be `const` or not
- Call it from `CheckGuessValidity()`*
- Simply return true for now inside `IsIsogram()`

Hint: you may need a not `!` *operator.*

Pseudocode IsIsogram()

- Only write comments for now
- Indent the comments as necessary
- Avoid code in the comments, work at a high level
- Run through mentally with some examples.

Range-based for Loop

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In This Video...

- Introducing containers and iterators
- Using a range-based `for` loop in Unreal*
- Gently introducing the `auto` keyword
- Finishing our `IsIsogram()`

*https://www.unrealengine.com/blog/ranged-based-for-loops

`std::map` syntax

- `TMap<char, bool> LetterSeen;` to declare
- Using `LetterSeen[Letter]` to access
- You can assign to the map element
- e.g. `LetterSeen[Letter] = true;`

`std::unordered_set` or Unreal `TSet` is a valid alternative. Map is a more versatile.

Finish `IsIsogram()`

- Finish the function
- Test it thoroughly
- Try entering just \0 as a guess
- Try a blank string
- Try mixed case e.g. Aa
- Share your implementation in the discussions.

Design a Helper Function

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In This Video...

- Gain confidence with a multi-stage challenge
- A word on implicit dependencies.

Get lowercase checking working

- Declare and define `IsLowercase()` helper
- Use a range-based `for` loop
- Use the `auto` keyword
- Handle strings of zero length, ‘\0’ and spaces
- Hint: a method called `islower()` may help
- Share your solution for discussion
- Succeed of F.A.I.L. - pat yourself on the back.

Avoid Implicit dependencies

Implicit: suggested though not directly expressed.
Dependent: reliant on something else.

An implicit dependency is when it's not completely clear that one thing depends on another. For example the order of checks in `CheckGuessValidity().`

Playtesting Your Game

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In This Video...

- Having someone else play test your game is vital
- Silently take notes, or record screen if possible
- Immediately go away and fix obvious bugs
- For improvements consider 2nd or 3rd opinion
- Repeat until the bug / issue rate plateaus.

Playtest the game

- Find somebody else, Skype if needed
- Share the bugs / improvements in Discussions
- Make it clear which version you’re commenting on
- Also play-test my game, download from…

https://github.com/UnrealCourse/02_BullCowGame/archive/master.zip

My playtesting actions (thanks Lizzie)

- Remove new line before bull cow count
- Tell user how many guesses they have left
- All a bit “left brain”, needs some ASCII art
- Spelling error in “Better luck next time!”

Difficulty & Play Tuning

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In This Video...

- About the flow channel*
- `map` word length to max tries
- Play test to determine correct difficulty.

* *Read more in Sylvester, T. Designing Games - O'Reilly*

Map word length to max tries

- Populate your word length : max tries map
- Do more play testing to find the “sweet spot”
- Do this for at least 4-6 letter words
- Optionally: let user select word length.

Polishing & Packaging

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In This Video...

- First impressions count (think reviews)
- Don’t ship a half-baked product, even if digital
- Check through your code (polish)
- Ship to your customers (package).

Polish your game

- Comment with “why”, remove obvious comments
- Introduce your classes with block comments
- Use `#pragma once` at the top of each file
- Deal with or delete any TODO items
- Capture future ideas / improvements.

Ship your game

- Zip up **source code** (not .exe or .app) and share in discussions via DropBox, Drive, YouSendIt etc
- Ensure code is in runnable state and archive
- Celebrate your success - seriously.

Section Wrap-Up

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In This Video...

- HUGE congratulations on your progress
- Over 6 hours of pure C++ learning
- Over 30 challenges you've completed
- The journey has only just begun
- Share your source code for others to play
- Here are some suggested improvements
- Next we take the game logic into Unreal :-)

Suggested improvements

- Easy, medium, hard which changes max tries
- Explain what an isogram is in the text*
- Define bulls and cows to the user*
- Explain the rules of the game more fully*

** consider only doing these on the 1st play*

Further Reading

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Symbols In Your IDE

Meaning of symbol in autocomplete	**VS 2015**[1]	**Xcode**[2]
Class or Struct	◆ ▤	C
Property or Field	◆	F
Method or Function	⬡	M
Namespace	{ }	N
Macro e.g. UPROPERTY() or #include	▶	#

1. https://msdn.microsoft.com/en-us/library/y47ychfe.aspx
2. http://stackoverflow.com/questions/6662395/xcode-intellisense-meaning-of-letters-in-colored-boxes-like-f-t-c-m-p-c-k-etc

Streams & Flushing

```
std::cout << std::endl; // Equivalent to...
std::cout << '\n' << std::flush;
```

http://www.cprogramming.com/tutorial/c++-iostreams.html

http://www.cprogramming.com/tutorial/c++-iostreams.html

Parameter vs. Argument

- They are two sides of the same coin
- They often get used interchangeably, but strictly...
- You **define parameters**
- You call with **argument(s)**

http://stackoverflow.com/questions/156767/whats-the-difference-between-an-argument-and-a-parameter

Unreal Coding Standards

- We will use a slightly different { } strategy.
- This is to save vertical space on the screen.
- Otherwise we'll generally stick to these*

*https://docs.unrealengine.com/latest/INT/Programming/Development/CodingStandard/index.html

Unreal's `TSet` & `std::unordered_set`

"Unordered sets are containers that store unique elements in no particular order, and which allow for fast retrieval of individual elements based on their value."

This is ideal alternative for our `SeenLetters` container. Thanks to Daniel for bringing this up.

Braced Initializers

- `int32 AgeInYears {24};` initialisation syntax
- Prevents “narrowing conversions” e.g.
- `int32 AgeInYears {24.3};` ⇐ error
- `int32 AgeInYears = 24.3;` ⇐ narrows to 24
- Defaults to the right empty value
- `e.g. char PreviousChar {}`
- Compatible with lists and other containers.