kscript

Scripting Enhancements for Kotlin

Holger Brandl

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KotlinConf

kscript - Scripting Enhancements for Kotlin

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What are language requirements for data-driven science?

Why Kotlin may be the right choice.

How `kscript` provides enhanced scripting support for Kotlin.

Language requirements for data-driven science

1. Reproducible: Can we reproduce results at a later date?

2. Rapid Prototyping: Can we quickly setup an analysis?

3. Scalable: Can we upscale scripts into systems and tools?

4. Community: Can we enable colleagues to analyze data?

Use just the linux shell for data-driven science?

> But it's faster and way shorter to do it bash! (unknown colleague)

Do *magical* things in the terminal without dependencies

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perl -ne 'unless((!($_=~/^@.*/)&&!(m/AS:i:/))||(m/AS:i:(\S+).+XS:i:(\S+)/ && $1-$2<1)){p
}

bowtie2 $fastqFile | samtools view -SF 4 -  | removeMultiMappers | samtools sort - resul
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Get published and forget.

Fast to write. Impossible to maintain or to evolve. Does not scale. Unteachable black art.

Java for Data Science?

2001 - First contact:

> **Evolving image processing for 2d gel electrophoresis analysis**

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- Static typing provides guidance and context
- Type- and compile-time checking of code
- Ease of deployment
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- Rerun apps again and again
- Lack of interactivity

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- Lack of interactivity

Java allows to write complex software but fails for explorative analysis and prototyping.

Java for Data Science?

1. Reproducible: Can we reproduce results at a later date? ✓
2. Rapid Prototyping: Can we quickly setup an analysis? ✗
3. Scalable: Can we upscale scripts into systems and tools? ✓
4. Community: Can we enable colleagues to analyze data? ✗

Most popular choices for data science?

R stronger for statistics and explorative data-analysis (dplyr, tidyr, rstudio).

Python more popular for machine learning (kaggle, keras, scikit)

Both are fun to teach and great for prototyping.

Python Dependencies: The *best* practice

```
virtualenv my_scikit

source my_scikit/bin/activate

pip install -U scikit-learn

## actual logic goes in here!
/sw/bin/python -c '
from sklearn import datasets
... the cool stuff!
'

deactivate
```

- Per project index only via `virtualenv`, which is tedious for small scale tasks
- No binaries, always (slowly) compiles from scratch

No sound way to manage dependencies in python

R dependencies

- No built-in way to indicate a specific dependency version for a project
- Also declaration of package-dependencies is sloppy by design

```
Imports: assertthat, bindrcpp (>= 0.2), glue (>= 1.1.1), magrittr,
        methods, pkgconfig, rlang (>= 0.1.2), R6, Rcpp (>= 0.12.7),
        tibble (>= 1.3.1), utils
```

- Existing approaches like packrat are no yet ready for prime time: build package index from scratch per project

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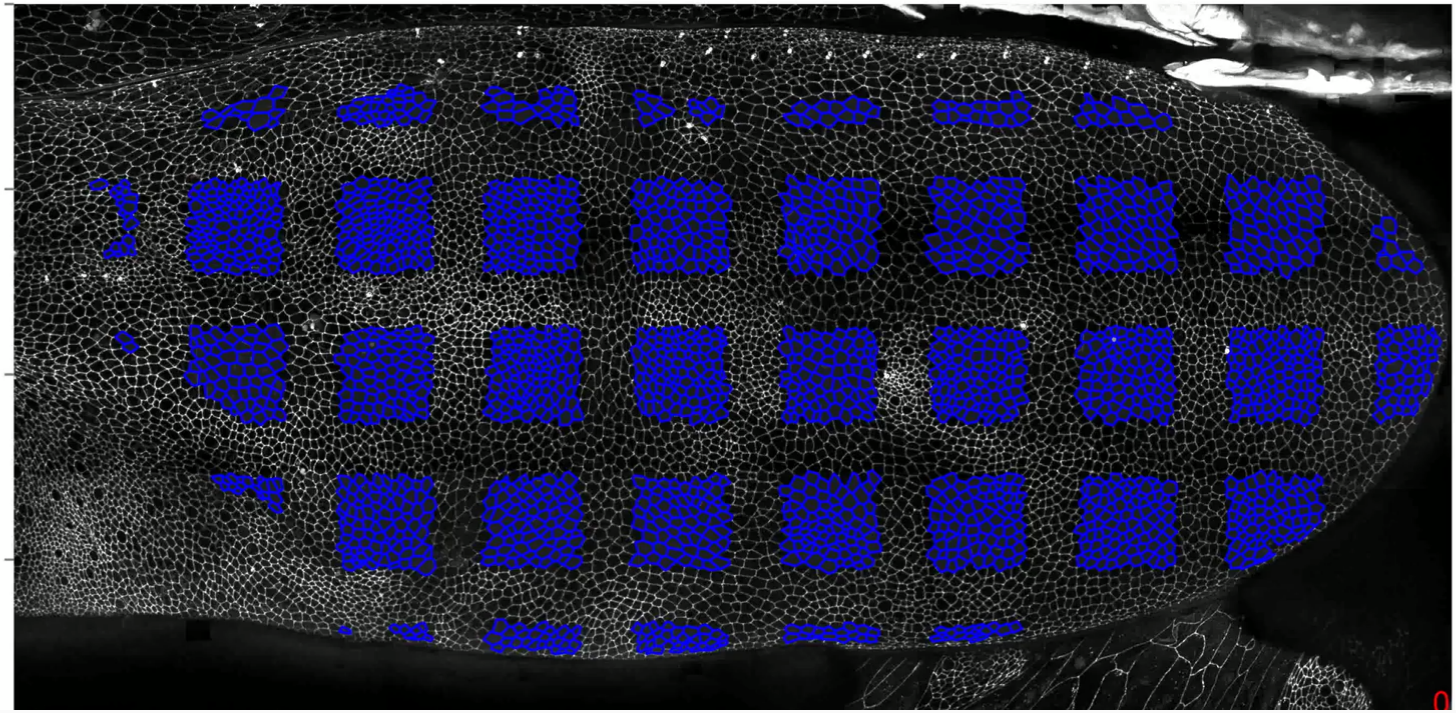
Python and R fail to be *the* solution for data science

1. Reproducible: Can we reproduce results at a later date? ✗
2. Rapid Prototyping: Can we quickly do setup an analysis? ✓
3. Scalable: Can we upscale scripts into systems and tools? ✗
4. Learning curve: Can we enable colleagues to analyze data? ✓

How to deploy software for data-driven science?

Webservices don't scale with data. Bring tools to users. Example:

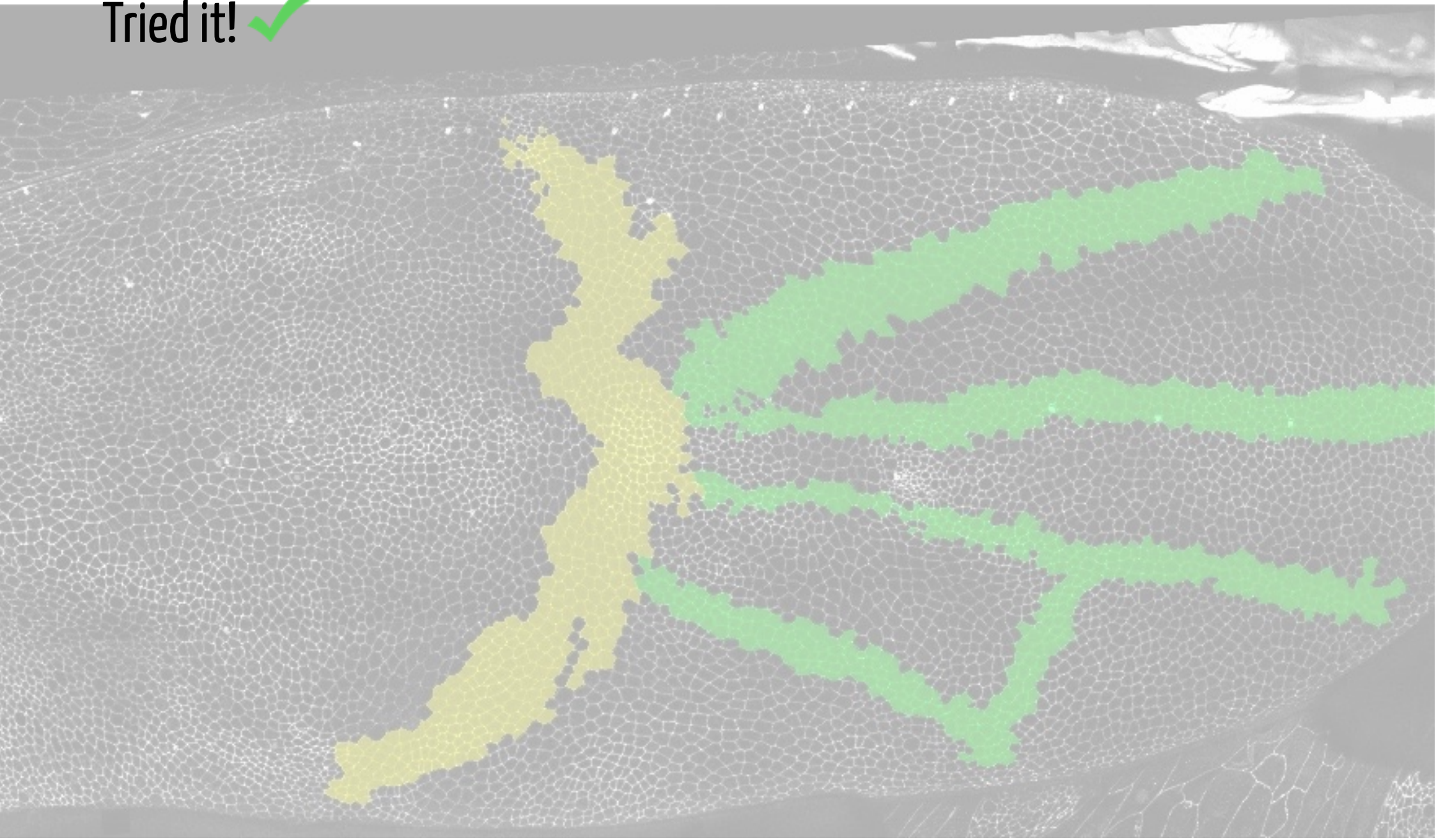
> Raphael Etournay, Marko Popović, Matthias Merkel, Amitabha Nandi, Corinna Blasse, Benoit Aigouy, Holger Brandl, Gene Myers, Guillaume Salbreux, Frank Jülicher, Suzanne Eaton
> **Interplay of cell dynamics and epithelial tension during morphogenesis of the Drosophila pupal wing.**
> *Elife* , 4 Art. No. e07090 (2015)




How to ship it to the community?


How to ship it to the community?
Dockerize it!

Tried it! ✓



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Sucessfully published! ✓

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```
alias tm='docker run --rm -ti -v $(dirname $PWD):/movies etournay/tissue_miner'

tm analyze_sheer <image_data>
tm track_cell_divisions <image_data>
```

Tried it! ✓

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Doing *just* docker-support since then. ✗

A better way to do data science?

- Reproducibility, Dependencies & Scalability: **Java**
- Prototyping & Community: **R & Python**

Fusion would be great:

Java with the ease of a scripting language

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eierlegende Wollmilchsau

February 2016

Kotlin v1.0 released

Type Inference

Extension Functions

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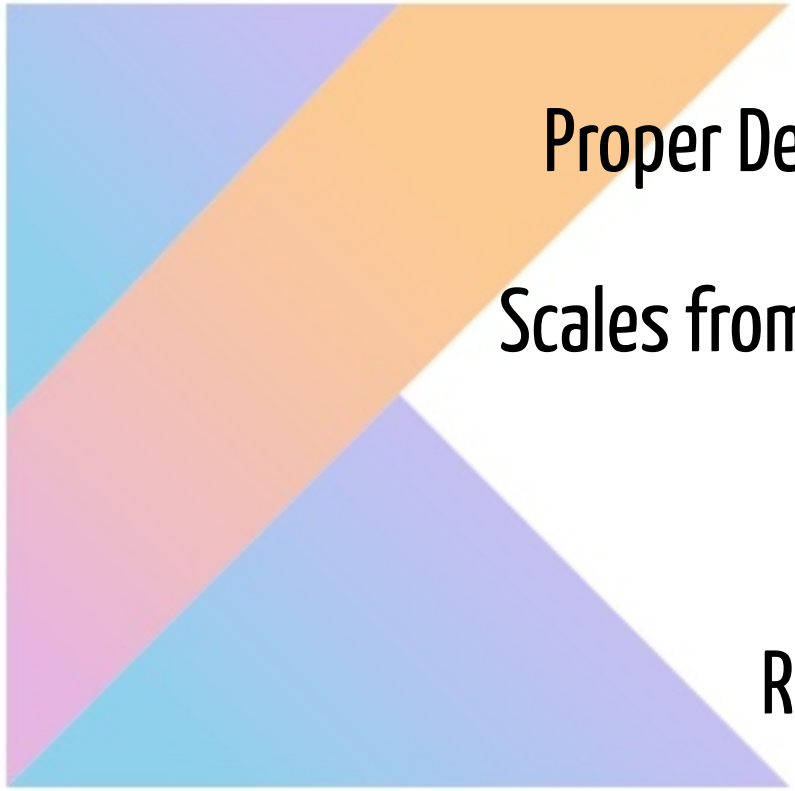


Data Science Requirements

Proper Dependency Model ✓

Scales from idea to product ✓

Teachable ✓

Rapid Prototyping ??

Let's write a script!

```
kotlinc -script pipeline_prototype.kts
```

which is equivalent to

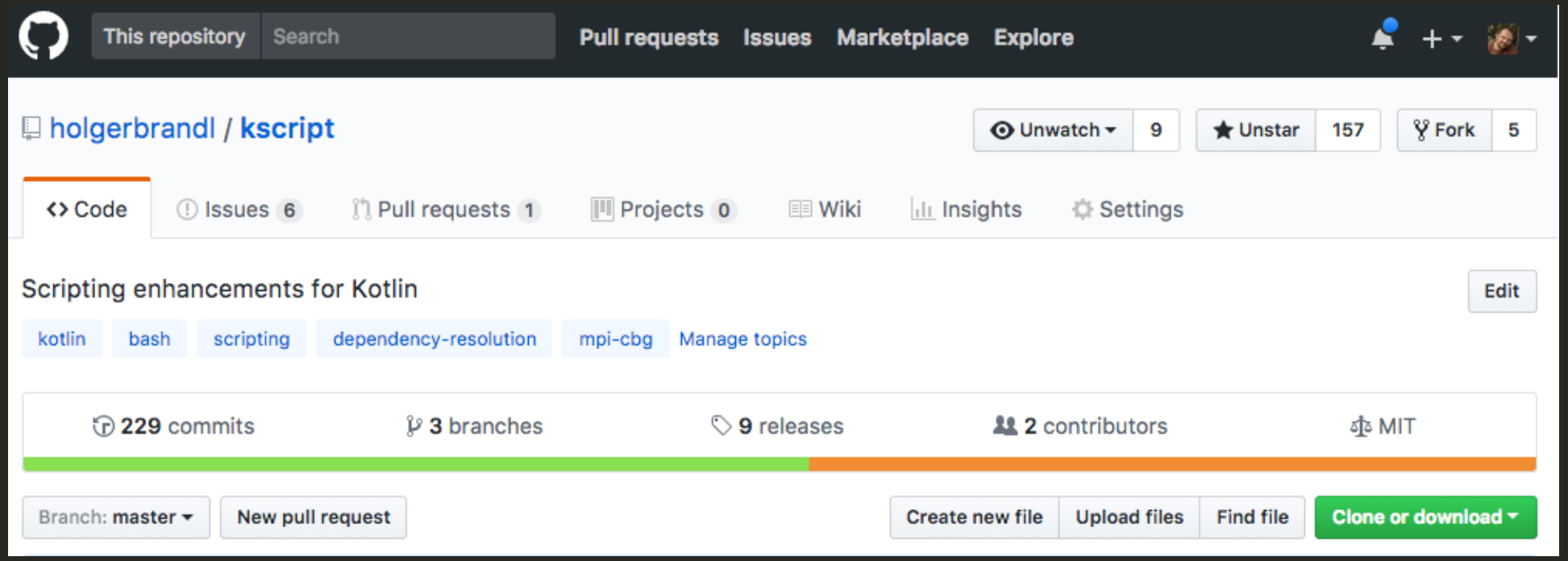
```
#!/usr/bin/env kotlinc -script

println("do stuff")

val data = readData() // not quite yet!
```

Issues with existing out-of-the-box `kotlinc` tooling

- How to pull in dependencies? `kotlinc -cp ...` seems too tedious. A separate gradle/maven file even more.
- `kotlinc` means recompile, so little scriptlets run slow
- How to keep track of required JVM/runtime options?
- More flexible way to provide scripts



Since March 2016

Enhanced scripting support for Kotlin on *nix-based systems.

> `kscript` provides an easy-to-use, very flexible, and almost zero-overhead solution to write self-contained mini-applications with Kotlin.

Core features of `kscript`

Wraps `kotlinc` and adds

Compiled script caching (using md5 checksums)

Dependency declarations using gradle-style resource locators

More options to provide scripts

Embedded runtime options

Support library to ease the writing of Kotlin scriptlets

```
# sdk install kscript  ## for details see http://sdkman.io/
kscript --help
```

```
kscript - Enhanced scripting support for Kotlin on *nix-based systems.

Usage:
kscript [options] <script> [<script_args>]...
 kscript --clear-cache
 kscript --self-update

The <script> can be a  script file (*kts), a script URL, - for stdin, a *.kt source file
with a main method, or some Kotlin code.

Use '--clear-cache' to wipe cached script jars and urls
Use '--self-update' to wipe cached script jars and urls

Options:
 -i --interactive        Create interactive shell with dependencies as declared in script
 -t --text               Enable stdin support API for more streamlined text processing
 --idea                  Open script in temporary Intellij session

Copyright : 2017 Holger Brandl
License   : MIT
Version   : v2.1.0
Website   : https://github.com/holgerbrandl/kscript
```

Input Modes

There's a multitude of ways to serve a script to `kscript`

The `<script>` argument can be a

- script file (*kts),
- a script URL,
- – for stdin,
- some kotlin code
- a `*.kt` source file with a main method,

Interpreter Usage

To use `kscript` as interpreter for a script `Example.kts` just point to it in the shebang line

```
#!/usr/bin/env kscript

println("hello world")
```

We can still run it directly with

```
kscript Example.kts
```

Or make executable and run directly

```
chmod +x Example.kts

./Example.kts
```

Inlined Usage

Use `kscript` in a workflow without creating an additional script file.

- Directly provide a Kotlin scriptlet as argument

```
kscript 'println("hello world")'
```

- Pipe a Kotlin snippet into `kscript` and instruct it to read from `stdin` by using `-` as script argument

```
echo '
println("Hello Kotlin.")
' |  kscript -
```

- Use `heredoc` (preferred solution for inlining) which gives more flexibility. E.g. use single quotes in script

```
kscript - <<"EOF"
println("It's a beautiful day!")
EOF
```

`kscript` can launch apps right from the internet

Example:

```
kscript 'https://git.io/v9R73' arg u ments
```

To streamline the usage, the first part could be even aliased:

```
alias hello_kscript="kscript https://git.io/v1cG6"
hello_kscript my argu ments
```

- Support remote tool repositories
- Allows for easy integration of remotely hosted (mini) programs into data pipelines
- Installation-free
- URLs are assumed to be static and will be cached via checksum.

Write command line tools with *just* the standard library

```
#!/usr/bin/env kscript

val stdin: Sequence<String> = generateSequence { readLine() }

stdin
    // retain only lines starting with digits 0 to 5
    .filter{ it.contains("^[0-5]{5}".toRegex()) }
    // add prefix
    .map { "id" + it }
    // print to stdout
    .forEach { println(it) }
```

Would work using `kotlinc -script` as interpreter as well, but would be painfully slow

Be snappy by caching compiled scripts

`kscript` execution model

1. Calculate md5 of input script
2. Look up cached jar by md5; if not yet present create it
3. Use process substitution to replace `kscript` with `kotlin` process

All *kscripts* are cached based on `md5` checksum, so running the same snippet again will be much faster

The cache directory is `~/.kscript` and can be cleared with `kscript --clear-cache`

Directives

> Script sources are (often) not enough to … *write self-contained mini-applications with Kotlin.* (from kscript README)

Directives supported by `kscript`:

`//DEPS`	Declare dependencies with gradle-style locators
`//KOTLIN_OPTS`	Configure the kotlin/java runtime environment
`//INCLUDE`	Source kotlin files into the script
`//ENTRY`	Declare application entrypoint for kotlin `*.kt` applications

Declare dependencies with `//DEPS`

```
#!/usr/bin/env kscript

//DEPS com.beust:klaxon:0.24, com.github.kittinunf.fuel:fuel:1.3.1
import com.beust.klaxon.*
import com.github.kittinunf.fuel.httpGet

require(args.isNotEmpty()) {
    println("Usage: id_converter <some_id>+")
    kotlin.system.exitProcess(-1)
}

val queryURL = "http://foo.com/bar?convert=${args.joinToString(",")}"
val json = String(queryURL.httpGet().response().second.data)
val jsonArray = Parser()
    .parse(json.byteInputStream())!! as JsonArray<*>

// use klaxon library to parse the json result
val conversionTable = jsonArray.map { (it as JsonObject) }.map {
    it.int("id") to it.string("converted")
}.forEach { println(it) }
```

Run as tool with just `id_converter.kts 232 42323 23`

Configure the runtime with `//KOTLIN_OPTS`

Just passed on to `kotlin`.

Example: Filter dna-sequences by length

```
#!/usr/bin/env kscript

//DEPS de.mpicbg.scicomp:kutils:0.4
//KOTLIN_OPTS -J-Xmx5g -J-server

import de.mpicbg.scicomp.bioinfo.openFasta

if (args.size != 2) {
    System.err.println("Usage: fasta_filter <fasta> <max_length>")
    kotlin.system.exitProcess(-1)
}

val fastaFile = java.io.File(args[0])
val lengthCutoff = args[1].toInt()

openFasta(fastaFile).
        filter { it.sequence.length <= lengthCutoff }.
        forEach { print(it.toEntryString()) }
```

Ease prototyping with //INCLUDE

Many other languages allow to directly include source files. Can we do the same in Kotlin? Yes, with `kscript`!

```
//utils.kt
fun Array<Double>.median(): Double {
    val (lower, upper) = sorted().let { take(size / 2) to takeLast(size / 2) }
    return if (size % 2 == 0) (lower.last() + upper.first()) / 2.0 else upper.first()
}
```

Artifacts are the proper way!

`kscript` allows to skip artifact deployment by using `//INCLUDE`

```
#!/usr/bin/env kscript


//INCLUDE utils.kt
//INCLUDE https://github.com/krangl/blob/src/MathHelpers.kt

val robustMean = listOf(1.3, 42.3, 7.).median()
println(robustMean)
```

Use `//ENTRY` to run applications with `main` method

`kscript` also supports running regular Kotlin `kt` files.

Example: `./examples/Foo.kt`:

```
package examples

//ENTRY examples.Bar

class Bar{
    companion object {
        @JvmStatic fun main(args: Array<String>) {
            println("Foo was called")
        }
    }
}

fun main(args: Array<String>) =  println("main was called")
```

To run top-level main instead we would use `//ENTRY examples.FooKt`

The latter is the default for `kt` files and could be omitted

Replace awkward terminal programming with Kotlin

`kscript` can be used as a speedier and more flexible substitute for built-in terminal tools such as `awk` or `sed`

Use `-t`/`--text` to enable a support API for line-based text processing

- Delete a column

```
awk '!($3="")'  some_flights.tsv
kscript -t 'lines.split().select(-3).print()' some_flights.tsv
```

- Delete trailing white space (spaces, tabs)

```
awk '{sub(/[ \t]*$/, "");print}' file.txt
kscript -t 'lines.map { it.trim() }.print()' file.txt
```

See https://github.com/holgerbrandl/kscript-support-api and kscript as substitute for awk

Pimp your REPL with `--interactive`

```
#!/usr/bin/env kscript
//DEPS de.mpicbg.scicomp:kutils:0.4
import de.mpicbg.scicomp.bioinfo.openFasta

if (args.size != 1) {
    System.err.println("Usage: CountRecords <fasta>")
    kotlin.system.exitProcess(-1)
}

val records = openFasta(java.io.File(args[0]))
println(records.count())
```

Pimp your REPL with `--interactive`

```
#!/usr/bin/env kscript
//DEPS de.mpicbg.scicomp:kutils:0.4
import de.mpicbg.scicomp.bioinfo.openFasta

if (args.size != 1) {
    System.err.println("Usage: CountRecords <fasta>")
    kotlin.system.exitProcess(-1)
}

val records = openFasta(java.io.File(args[0]))
println(records.count())
```

Bootstrap interactive shell from your script.

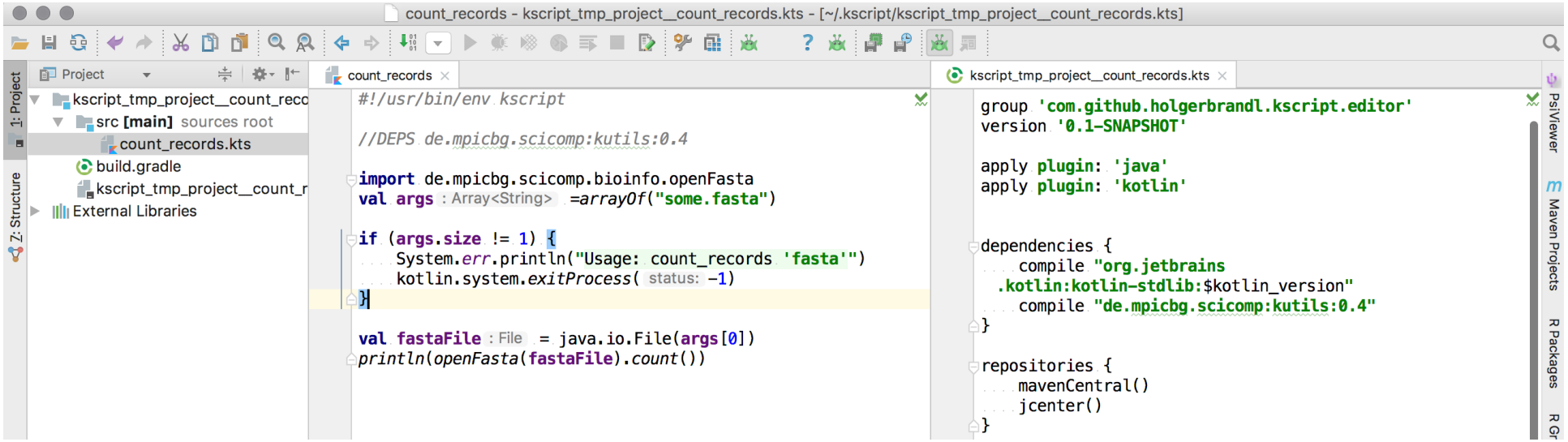
```
kscript --interactive CountRecords.kts
```

```
Creating REPL from /Users/brandl/Dropbox/kscript_kotlinconf_2017/code_examples/count_records.kts
Welcome to Kotlin version 1.1.51 (JRE 1.8.0_151-b12)
>>> import de.mpicbg.scicomp.bioinfo.openFasta
>>>
```

Bootstrap projects from scripts with `--idea`

- Artifacts and versions will differ between scripts
- `kscript` allows to create temporary project from script using Gradle

```
kscript --idea CountRecords.kts
```



Requires command-line launcher `idea` to be setup via `Tools->Command Line Launcher`

What's next?

Replace comment // directives with annotations

Using proper file annotations would be better design and also allow for better tooling

```
// DEPS log4j:log4j:1.2.14
//vs
@file:DependsOn("log4j:log4j:1.2.14")
```

Replace comment / / directives with annotations

Using proper file annotations would be better design and also allow for better tooling

```
// DEPS log4j:log4j:1.2.14
//vs
@file:DependsOn("log4j:log4j:1.2.14")
```

No such thing as `DependsOn` in kotlin stdlib. To enable correct code parsing add `com.github.holgerbrandl:kscript-annotations:1.0` as dependency to the Intellij project

```
#!/usr/bin/env kscript

@file:DependsOn("de.mpicbg.scicomp:kutils:0.4")
@file:DependsOn("com.beust:klaxon:0.24", "com.github.kittinunf.fuel:fuel:1.3.1")

@file:KotlinOts("-J-server")  vararg args: String
@file:KotlinOpts("-J-Xmx5g")

@file:Include("util.kt")
@file:EntryPoint("Foo.bar") // applies on for kt-files


print("do something really cool here!")
```

Getting serious about scripting with KEEP #75

Great proposal that aims to unify various aspects of scripting in a common API

- Define Kotlin scripting and it's applications
- Describe intended use cases for the Kotlin scripting
- Provide sufficient control of interpretation and execution of scripts
- Provide usable default components and configurations for the typical use cases

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Some core aspects are implemented by `kscript`!

- IDE/tooling support via `--idea`
- Project-level REPL `--interactive`
- Directives/annotations to declare dependencies and modulate the runtime environment

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Some core aspects are implemented by `kscript`!

- IDE/tooling support via `--idea`
- Project-level REPL `--interactive`
- Directives/annotations to declare dependencies and modulate the runtime environment

Will it kill `kscript`? Maybe.

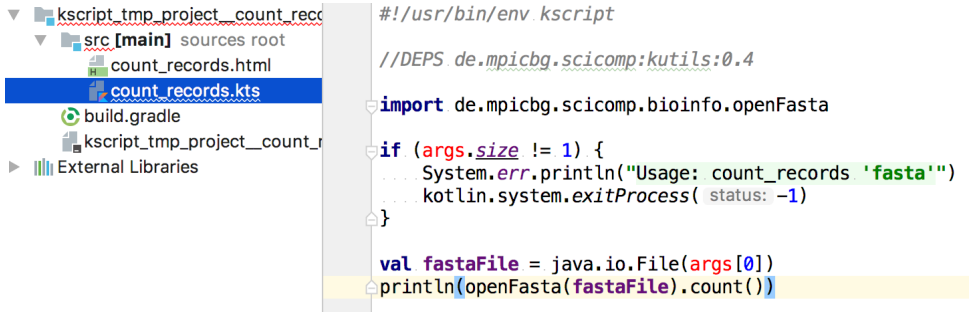
Looking forward to tool convergence!

Next steps?

- Go `kotlin-native` to remove ~200ms JVM launch overhead

```
exec $(kotlin -classpath ${jarPath} kscript.app.KscriptKt "$@")
```

- Support for custom artifact repositories
- Pray for KT-16802 *Good code is always red when editing kts-script files under Kotlin v1.1* to become fixed



Not much left to do. :-) Don't get infected by *featureritis*!

`kscript` is unit- and battle-tested, and ready production!

Dream, dream, dream...

- Revise annotation-driven script configuration once KEEP75 Scripting API supports it
- Use kohesive/keplin-maven-resolver for dependency resolution instead of `mvn`
- DSL-support: Derive new interpreters from `kscript`

```
#!/usr/bin/env tornando-fx-script

class HelloWorld : View() {
    override val root = hbox {
        label("Hello world")
    }
}
```

- <*your ideas here!*> just go to https://github.com/holgerbrandl/kscript

What's still missing in Kotlin to rule data-science?

1. **Interactivity**: Improve jupyter-kernel support (interactive usage, idea notebook editor support)
2. **More Kotlin DataScience APIs** for modeling (pandas, dplyr) and visualization (ggplot2, seaborn, d3)
3. **Fix the REPL** to be not just a `re` wihout `pl`
4. **Data-Science IDE** Provide a *cut down* version of IJ for data science

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4. **Data-Science IDE** Provide a *cut down* version of IJ for data science

```
>>> fun md5(byteProvider: () -> ByteArray): String {
...     val md = MessageDigest.getInstance("MD5")
...     md.update(byteProvider())
...
...     val digestInHex = bytesToHex(md.digest()).toLowerCase()
...
...     return digestInHex.substring(0, 16)
... }
```

What's still missing in Kotlin to rule data-science?

1. **Interactivity**: Improve jupyter-kernel support (interactive usage, idea notebook editor support)
2. **More Kotlin DataScience APIs** for modeling (pandas, dplyr) and visualization (ggplot2, seaborn, d3)
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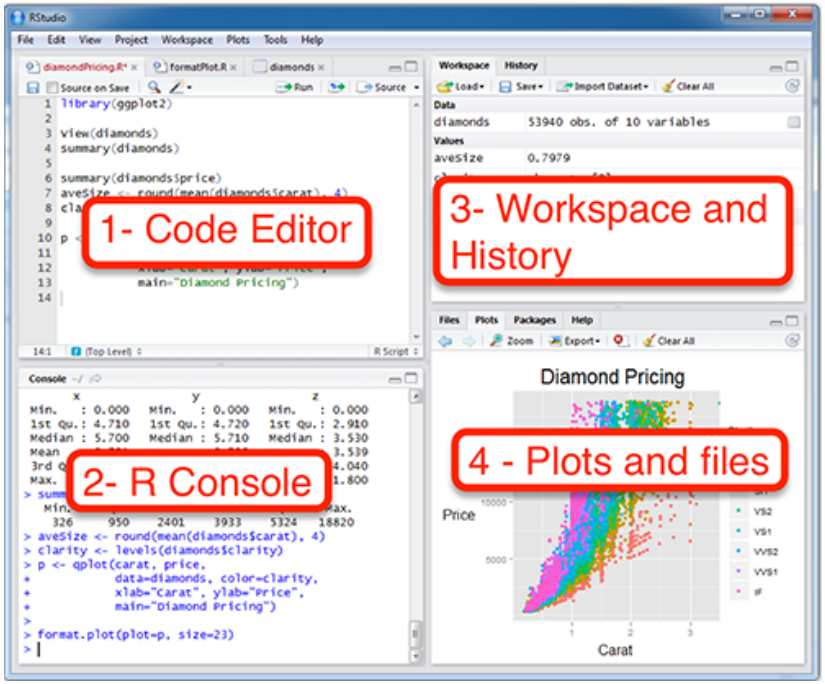

Summary

Kotlin may be the right choice for data science.

`kscript` provides enhanced scripting support for Kotlin.

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Questions and pull requests are welcome.

For these slides, more docs, examples see https://github.com/holgerbrandl/kscript

Thanks for your attention.

Thanks to the contributors of `kscript` for their great feedback and help.