



LEIDEN UNIVERSITY MEDICAL CENTER

Combining tools into a pipeline

Jeroen F. J. Laros

Leiden Genome Technology Center

Department of Human Genetics

Center for Human and Clinical Genetics



Pipelines



Figure 1 : A real-life pipeline.

Pipelines



Figure 2 : Scene from “Modern times”.

Pipelines

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- Not necessarily linear.
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Running various different tools:

- Two or three different aligners.
- A couple of variant callers.
- ...

Running example: Exome sequencing

In *exome sequencing*, we select genomic regions of interest using a *target-enrichment strategy*.

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- Fragmentation.
- Size selection.
- Linker ligation.
- Capture.

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These regions are then *sequenced*.

Sequencers: HiSeq



Figure 3 : HiSeq 2000.

Characteristics:

- High throughput.
- Paired end.
- High accuracy.
- Read length $2 \times 150\text{bp}$.
- Relatively long run time.
- Relatively expensive.

Sequencers: Ion Torrent



Figure 4 : Ion torrent.

Characteristics:

- Moderate throughput.
- Single end (for now).
- High accuracy.
- Read length $\pm 200\text{bp}$.
- Short run time.
- Cheap runs.

Data analysis

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4. Filtering.
 - Post-variant calling quality control.
5. Annotation.

Trimming

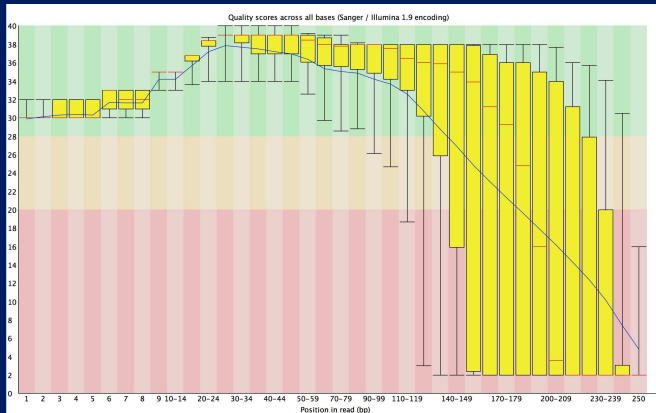


Figure 5 : Quality score per position.

Clipping

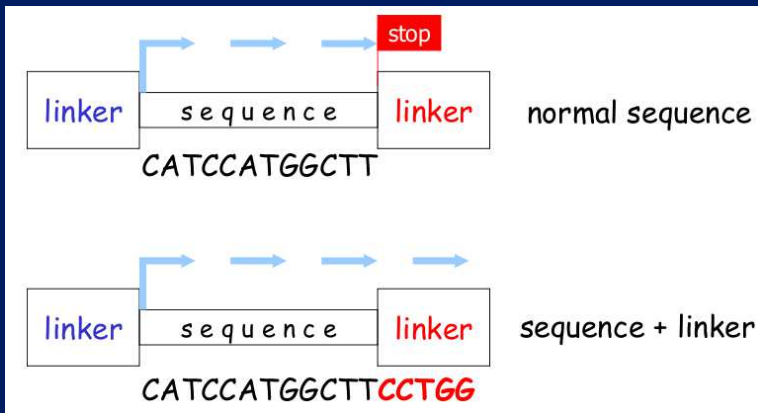


Figure 6 : Sequencing linkers.

Data cleaning and QC

Depending on the sequencing platform, parts of the reads need to be removed.

- Remove linker sequences (*Cutadapt, FASTX toolkit*).
- Clip low quality reads at the end of the read (*Sickle, Trimmomatic, FASTX toolkit*).
- Length filtering (*Fastools*).

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The *FastQC toolkit* can be used for quality control (both before and after the data cleaning step).

- GC content.
- GC distribution.
- Quality scores distribution.
- ...

Pre-alignment

Example QC output

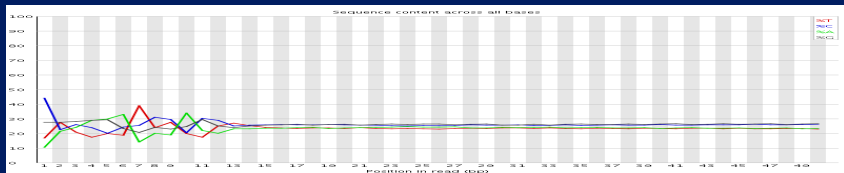


Figure 7 : Per base sequence content.

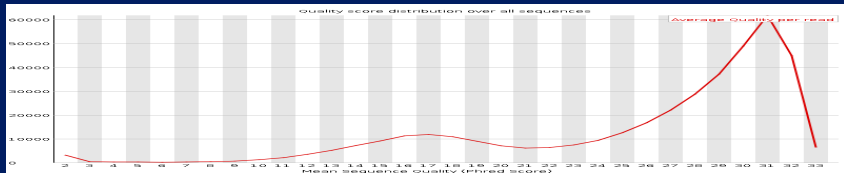


Figure 8 : Per sequence quality.

Choose an aligner

Alignment needs to be fault-tolerant.

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 - *GMAP* / *GSNAP*.
 - *Tophat*.
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The choice of aligner may be restricted by the sequencer.

- For the Ion Torrent: *Tmap*.
- For the PacBio: *BLASR*.

Variant calling

Pileup

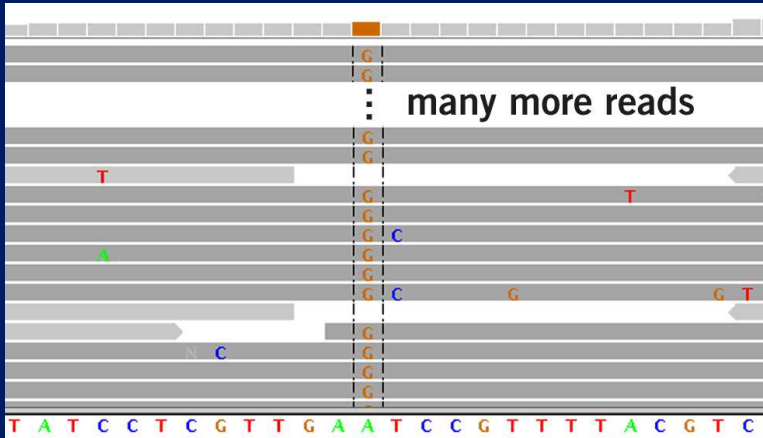


Figure 9 : Result of an alignment.

Some considerations

Things a variant caller might take into account:

- Strand balance.
- Base quality.
- Mapping quality.
 - Distribution within the reads.
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Popular variant callers:

- *Samtools*.
- *GATK*.
- *VarScan*.

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A good way to calculate the maximum:

- Calculate the mean coverage.
 - Only of the covered (targeted) regions.
- Multiply this number with a reasonable factor e.g., 2.5.

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 - Is it in the 5'/3' UTR of a gene?
 - ...
- Is it in a regulatory region?
- ...

Combining tools

```
1  bwa aln -t 8 $reference $i > $i.sai
2  bwa samse $reference $i.sai $i > $i.sam
3  samtools view -bt $reference -o $i.bam $i.sam
```

Listing 1 : Shell script

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Listing 1 : Shell script

```

1  %.sai: %.fq
2      $(BWA) aln -t $(THREADS) $(call MKREF, $@) $< > $@
3
4  %.sam: %.sai %.fq
5      $(BWA) samse $(call MKREF, $@) $^ > $@
6
7  %.bam: %.sam
8      $(SAMTOOLS) view -bt $(call MKREF, $@) -o $@ $<

```

Listing 2 : Makefile

Galaxy

Galaxy: a graphical user interface:

- Wrapper for command line utilities.
- User friendly.
- Point and click.

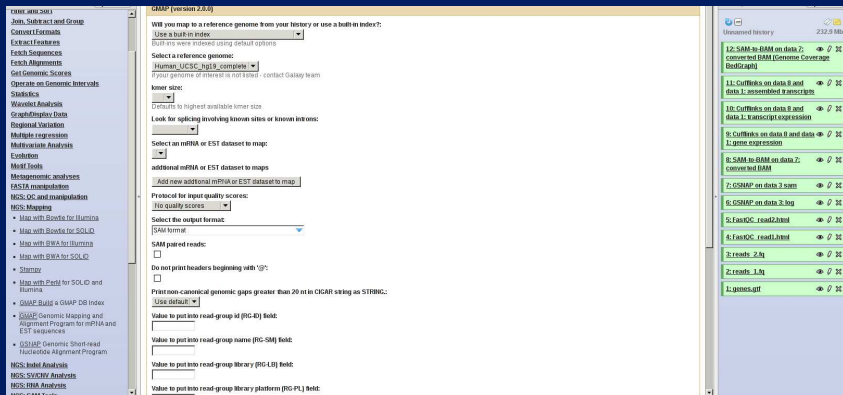
<http://galaxy.psu.edu/>

Galaxy

Galaxy: a graphical user interface:

- Wrapper for command line utilities.
- User friendly.
- Point and click.
- Workflows.
 - Save all the steps you did in your analysis.
 - Rerun the entire analysis on a new dataset.
 - Share your workflow with other people.
 - ...

<http://galaxy.psu.edu/>



The screenshot displays the Galaxy web interface. On the left is a navigation sidebar with categories like 'Tools, Subtools and Groups', 'Workset Analysis', 'Regional Variation', 'Multiple sequence', 'Multivariate Analysis', 'Evolution', 'Motif Tools', 'Metagenomic analyses', 'FASTA manipulation', 'NGS: QC and manipulation', 'NGS: Mapping', 'NGS: Index Analysis', 'NGS: SV/CRV Analysis', 'NGS: RNA Analysis', and 'NGS: BAM Tools'. The main panel shows the 'GMAP (version 2.8.0)' tool configuration. It includes sections for 'Will you map to a reference genome from your history or use a built-in index?', 'Select a reference genome:' (set to 'Human_UCSC_hg19_complete'), 'kmer size:', 'Look for splicing involving known sites or known introns:', 'Select an mRNA or EST dataset to map:', 'additional mRNA or EST dataset to maps', 'Protocol for input quality scores:', 'Select the output format:', 'SAM paired reads:', 'Do not print headers beginning with '@:', 'Print non-canonical genomic gaps greater than 20 nt in CIGAR string as STRING:', 'Value to put into read-group id (RG-ID) field:', 'Value to put into read-group name (RG-SM) field:', 'Value to put into read-group library (RG-LB) field:', and 'Value to put into read-group library platform (RG-PL) field:'. The right sidebar shows an 'Unmapped history' with a list of 12 items, including '12: SAM-to-BAM on data 2; converted BAM (Genome Coverage bedGraph)', '11: Cufflinks on data 8 and data 1; assembled transcripts', '10: Cufflinks on data 8 and data 1; transcript expression', '9: Cufflinks on data 8 and data 1; gene expression', '8: SAM to BAM on data 2; converted BAM', '7: OSNAP on data 3 sam', '6: OSNAP on data 2 log', '5: FastQC_read2.html', '4: FastQC_read1.html', '3: reads_2.bq', '2: reads_1.bq', and '1: genes.gtf'.

Figure 10 : Galaxy main user interface

MPileup

Compute genotype likelihoods:

True ▼

Compute genotype likelihoods and output them in the binary call format (BCF).

Output uncompressed BCF:

True ▼

Similar to the Genotype parameter, except that the output is uncompressed BCF, which is preferred for piping.

Input :

▼

Execute

Generate BCF or pileup for one or multiple BAM files. Alignment records are grouped by sample identifiers in @RG header lines. If sample identifiers are absent, each input file is regarded as one sample.

Generated By:

LUMC Interface Generator (0.1)

2011-09-03T14:29:36.793452Z

Based On:

RDF Definition of "MPileup"

2011-09-02T16:17:29.010890Z

Figure 11 : User friendly interface with Galaxy

Workflow of a parallel pipeline

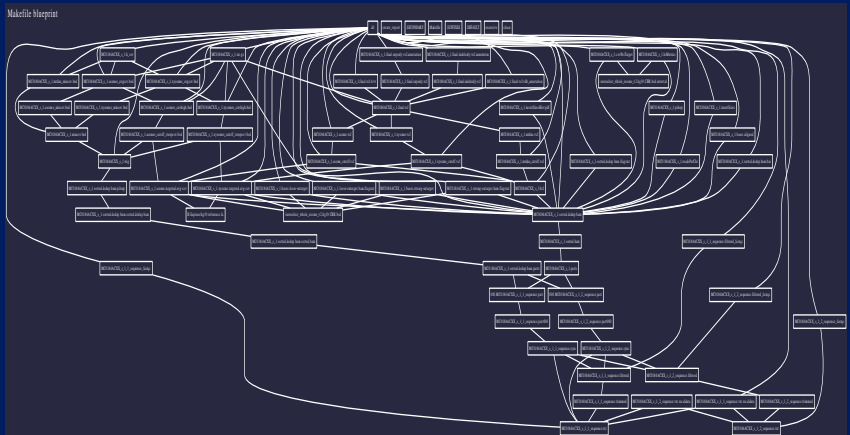


Figure 12 : Dependency diagram.

Graphical interfaces

Workflow of a parallel pipeline

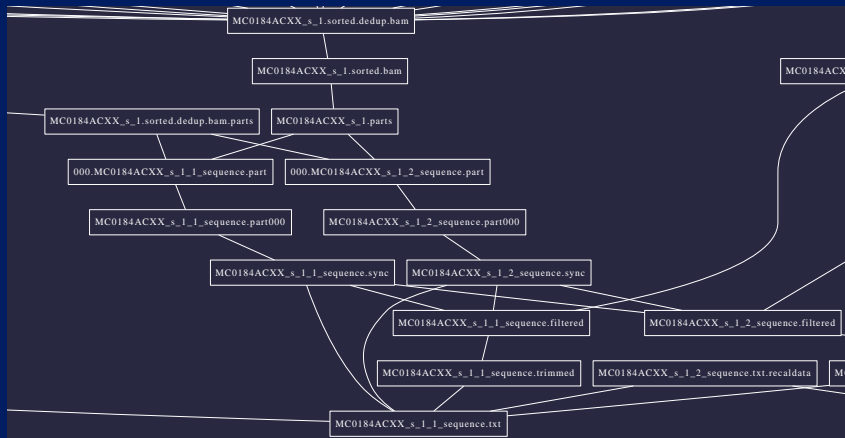


Figure 13 : Zoomed in.



Michiel van Galen
Jeroen Laros

<https://humgenprojects.lumc.nl/trac/humgenprojects/wiki/NGS-intro>