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`BamScale-package` *BamScale: Bioconductor-Friendly Multithreaded BAM Processing*

Description

Multithreaded sequential BAM processing built on top of the ompBAM C++ engine. BamScale provides user-friendly BAM read and scan interfaces designed for compatibility with existing Bioconductor workflows.

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See Also

Useful links:

- https://cparsania.github.io/BamScale/
- Report bugs at https://github.com/cparsania/BamScale/issues

---

`bam_count` *Count BAM records with Bioconductor-compatible filtering*

Description

`bam_count()` provides a fast chromosome-level count summary, honoring key filtering fields from `ScanBamParam` (`mapqFilter`, `flag`, and `which`).

Usage

```
bam_count(
  file,
  param = NULL,
  threads = 1L,
  BPPARAM = BiocParallel::bpparam(),
  auto_threads = FALSE,
  include_unmapped = TRUE
)
```

Arguments

file	BAM input (character, BamFile, or BamFileList).
param	Optional Rsamtools::ScanBamParam (or compatible list).
threads	Requested number of OpenMP threads. May be capped when auto_threads = TRUE.
BPPARAM	BiocParallel parameter for multi-file operation. Defaults to BiocParallel::bpparam(). Set to NULL to force serial file processing.
auto_threads	Logical; when TRUE and BPPARAM has multiple workers, BamScale adaptively avoids oversubscription by preserving higher per-file OpenMP thread counts when possible and reducing the number of concurrently active file workers before shrinking per-file threads.
include_unmapped	Whether to include an extra * row for unmapped records.

Details

Parallelism behavior matches bam_read(): BPPARAM distributes work across BAM files, while threads controls OpenMP work within each file. If auto_threads = TRUE and BPPARAM has multiple workers, BamScale first limits the number of concurrently active workers to preserve the requested per-file thread count within the detected core budget, then caps per-file OpenMP threads only if a single file would still oversubscribe the machine.

Value

For one file: a data.frame with columns seqname, seqlength, count. For multiple files: named list of such data.frames.

Examples

```
bam <- ompBAM::example_BAM("Unsorted")
bam_count(bam, threads = 2)
```

bam_coverage *Per-base coverage, aggregated in C++*

Description

Computes per-base read coverage by folding a per-contig difference array inside the multithreaded C++ reader and run-length encoding the result, without ever materialising the alignments as an R `GAlignments` object. This is the fast path for coverage / bigWig generation on large BAMs: the standard route (`GenomicAlignments::coverage(readGAlignments(file))`) builds a full `GAlignments` in R first, which is the dominant cost on 100M+-read files.

Usage

```
bam_coverage(
  file,
  param = NULL,
  threads = 1L,
  BPPARAM = BiocParallel::bpparam(),
  auto_threads = FALSE
)
```

Arguments

`file`	A BAM file path, Rsamtools::BamFile, or a vector / `BamFileList` of them.
`param`	Optional Rsamtools::ScanBamParam (or a compatible list). Only its `flag` and `mapqFilter` are honoured, applied per read in C++. With the default `NULL` the filter matches `readGAlignments()` (drop only unmapped reads). Note that `which` (region) restriction is not applied.
`threads`	Number of OpenMP threads for within-file decoding.
`BPPARAM`	A BiocParallel::BiocParallelParam for across-file parallelism when `file` has more than one element.
`auto_threads`	Logical; if `TRUE`, balance the thread / worker split.

Details

The result is **byte-identical** (`identical()`) to `GenomicAlignments::coverage(GenomicAlignments::readGAlignme`
CIGAR operations `M`, `=`, `X` and `D` contribute to coverage, `N` introduces a gap, and `I`/`S`/`H`/`P` are ignored; only unmapped reads (SAM flag `0x4`) are dropped by default – secondary, supplementary, duplicate and QC-fail reads are counted, exactly as `readGAlignments()` does.

Value

An IRanges::RleList (`SimpleRleList`) of integer coverage, one element per BAM-header sequence in header order, each of length equal to the header sequence length (contigs with no reads are all-zero runs). For multiple input files, a named list of such `RleLists`.

See Also

`fragment_sizes()`, `mapq_dist()`, `bam_read()`.

`bam_coverage_bigwig` *Write per-base coverage to a bigWig, computed in C++*

Description

Computes per-base coverage (identical to `bam_coverage()`) and writes it directly to a bigWig file entirely in C++ via the bundled libBigWig, without ever materialising the coverage as an R object. This is the fast path for generating coverage tracks from large BAMs: the usual route (`rtracklayer::export.bw(bam_coverage(file), out)`) round-trips a large `RleList` through R, and the serialisation dominates. Only non-zero coverage runs are written (uncovered bases are implicitly zero, the bigWig convention); importing the file reconstructs full-length coverage from the header lengths.

Usage

```
bam_coverage_bigwig(
  file,
  outfile,
  param = NULL,
  threads = 1L,
  BPPARAM = BiocParallel::bpparam(),
  auto_threads = FALSE,
  n_zooms = 10L,
  compress_level = -1L,
  parallel = TRUE,
  verbose = FALSE
)
```

Arguments

`file`	A BAM file path, Rsamtools::BamFile, or a vector / `BamFileList` of them.
`outfile`	Output bigWig path(s); must have the same length as `file`.
`param`	Optional Rsamtools::ScanBamParam (or a compatible list). Only its `flag` and `mapqFilter` are honoured, applied per read in C++. With the default `NULL` the filter matches `readGAlignments()` (drop only unmapped reads).
`threads`	Number of OpenMP threads for within-file decoding.
`BPPARAM`	A BiocParallel::BiocParallelParam for across-file parallelism when `file` has more than one element.
`auto_threads`	Logical; if `TRUE`, balance the thread / worker split.
`n_zooms`	Maximum number of bigWig zoom levels to generate (default `10`).
`compress_level`	Integer zlib deflate level for the bigWig blocks: `-1` (default) uses zlib's default (level 6, matching other bigWig writers); `1` to `9` trade file size for speed (`1` is the fastest write and gives the largest file). Coverage values are unaffected – only file size and write time change.
`parallel`	Logical; if `TRUE` (default), compress the bigWig data and zoom blocks across the OpenMP `threads` (deferred parallel compression). The output is byte-identical to serial compression. Set `FALSE` for the classic single-threaded write.
`verbose`	Logical; if `TRUE`, print a per-phase timing breakdown (coverage compute / interval write / zoom + index finalize) to stderr.

Details

The written values are identical to `GenomicAlignments::coverage(GenomicAlignments::readGAlignments(file))` (`M/=/X/D` contribute, `N` is a gap, `I/S/H/P` are ignored; only unmapped reads are dropped by default). Coverage values are integers stored as the bigWig `float` type, which is exact for depths up to `2^24`.

Value

The output path(s), invisibly.

See Also

`bam_coverage()` for the in-memory `RleList`.

`bam_read` *Fast BAM reading with Bioconductor-compatible arguments*

Description

`bam_read()` is a multithreaded sequential BAM reader built on top of `ompBAM`. The interface is designed to be familiar to users of `Rsamtools::scanBam()`, `GenomicAlignments::readGAlignments()`, and `GenomicAlignments::readGAlignmentPairs()`.

Usage

```
bam_read(
  file,
  param = NULL,
  what = NULL,
  tag = NULL,
  as = c("DataFrame", "data.frame", "GAlignments", "GAlignmentPairs", "scanBam"),
  seqqual_mode = c("compatible", "compact"),
  threads = 1L,
  BPPARAM = BiocParallel::bpparam(),
  auto_threads = FALSE,
  use.names = FALSE,
  with.which_label = FALSE,
  include_unmapped = TRUE
)
```

Arguments

`file`	A BAM input. Supported values are: • a single BAM path (`character(1)`) or multiple BAM paths, • a `Rsamtools::BamFile`, • a `Rsamtools::BamFileList`.
`param`	Optional `Rsamtools::ScanBamParam` (or a compatible list for lightweight use). The following fields are honored: `mapqFilter`, `flag`, `which`, `what`, and `tag`.
`what`	Character vector of fields to return, similar to `scanBam(what=...)`. Supported fields are `qname`, `flag`, `rname`, `strand`, `pos`, `qwidth`, `mapq`, `cigar`, `mrnm`, `mpos`, `isize`, `seq`, `qual`.

tag — Character vector of 2-letter tag names to extract.

as — Output format:

- "DataFrame": returns S4Vectors::DataFrame (default),
- "data.frame": returns base data.frame,
- "GAlignments": returns GenomicAlignments::GAlignments,
- "GAlignmentPairs": returns GenomicAlignments::GAlignmentPairs,
- "scanBam": returns a scanBam()-shaped list-of-lists.

seqqual_mode — Controls representation of seq/qual when those fields are requested:

- "compatible" (default): return character vectors matching scanBam-style expectations,
- "compact": return lower-level raw list-columns for faster/lower-overhead extraction. In compact mode, seq is returned as one raw vector per read containing BAM-native packed sequence bytes (two bases per byte), and qual is returned as one raw vector per read containing per-base Phred bytes. These are not plain character strings. qwidth is needed to decode compact seq back to base letters, and qual values of 255 correspond to missing quality values. This mode is currently supported for as = "data.frame" or as = "DataFrame".

threads — Requested number of OpenMP threads used for reading/decompression. May be capped when auto_threads = TRUE.

BPPARAM — BiocParallel parameter used when file contains more than one BAM. Defaults to BiocParallel::bpparam(). Set to NULL to force serial file processing.

auto_threads — Logical; when TRUE and BPPARAM has multiple workers, BamScale adaptively avoids oversubscription by preserving higher per-file OpenMP thread counts when possible and reducing the number of concurrently active file workers before shrinking per-file threads.

use.names — Passed to alignment object conversion. When TRUE, read names (qname) are used as object names.

with.which_label — Logical; if TRUE and param includes which, an extra which_label column is returned.

include_unmapped — Logical; whether unmapped records are retained (subject to param$flag constraints).

Details

bam_read() is intentionally column-compatible with common BAM fields used by Bioconductor workflows and can be used as a fast drop-in reader before conversion to downstream classes.

Parallelism model:

- BPPARAM parallelizes across files (one file per BiocParallel worker).
- threads parallelizes within each file via OpenMP.
- Effective total concurrency is approximately min(length(file), BiocParallel::bpnworkers(BPPARAM)) * threads.
- If auto_threads = TRUE and BPPARAM has multiple workers, BamScale first limits the number of concurrently active workers to preserve the requested per-file thread count within the detected core budget, then caps per-file OpenMP threads only if a single file would still oversubscribe the machine.

Compatibility notes:

- rname, mrnm, and strand are returned as factor columns, matching Rsamtools::scanBam(). rname/mrnm levels are the BAM header reference names; unmapped or unset references are NA (not "*"). strand has levels c("+", "-", "*").
- Region filtering via param$which is supported as a sequential filter (not index-jump random access).
- Flag filtering uses ScanBamFlag semantics by converting logical flag requirements into required-set and required-unset bit masks.
- Tag values are returned with their native BAM-derived type, matching scanBam(): integer-valued tags (c, C, s, S, i, I) become integer columns (or double when a value exceeds the R integer range), floating-point (f) tags become double columns, and A/Z/H/B tags become character columns. B tags are comma-separated character values. Absent tag values are NA.
- seqqual_mode = "compact" is optimized for throughput-oriented benchmarking and returns raw list-columns for seq/qual, not ordinary sequence or quality strings. In this representation, seq contains BAM-packed nucleotide bytes and qual contains raw Phred bytes. Compact output is intended for users who want to defer or avoid full string-materialization costs; use decode_compact_seq(), decode_compact_qual(), or decode_seqqual_compact() to decode compact output back to standard string form when needed.
- "GAlignments" and "GAlignmentPairs" output exclude unmapped records.
- as = "scanBam" returns a strict scan-like list-of-lists: without param$which, it returns one unnamed batch; with param$which, it returns one batch per range label (including empty ranges), with requested what fields and tag values under $tag. In this output mode, seq and qual are returned as Biostrings::DNAStringSet and Biostrings::PhredQuality for closer scanBam() compatibility.

Value

If file is length 1: one object in the format specified by as. If file has length > 1 (or is a BamFileList): a named list of outputs, one per BAM file.

Examples

```
bam <- ompBAM::example_BAM("Unsorted")

# Familiar scanBam-like field selection
x <- bam_read(bam, what = c("qname", "flag", "rname", "pos", "cigar"))

# Include sequence + quality
y <- bam_read(bam, what = c("qname", "seq", "qual"), threads = 2)

# scanBam-shaped output
z <- bam_read(bam, what = c("qname", "flag"), tag = "NM", as = "scanBam")
```

---

decode_compact_qual *Decode compact BamScale quality output*

Description

Decodes qual values returned by bam_read(..., seqqual_mode = "compact") back to ASCII Phred-quality strings.

Usage

```
decode_compact_qual(qual)
```

Arguments

qual	A list (or list-column) of raw vectors produced by compact BamScale quality extraction.

Value

A character vector containing decoded quality strings. Entries with all-missing quality bytes are returned as "*", matching BamScale's compatibility mode.

See Also

decode_compact_seq(), decode_seqqual_compact(), bam_read()

Examples

```
decode_compact_qual(
  qual = list(as.raw(c(0L, 1L, 2L, 3L)))
)
```

---

decode_compact_seq *Decode compact BamScale sequence output*

Description

Decodes seq values returned by bam_read(..., seqqual_mode = "compact") back to ordinary character strings.

Usage

```
decode_compact_seq(seq, qwidth)
```

Arguments

seq	A list (or list-column) of raw vectors produced by compact BamScale sequence extraction.
qwidth	Integer vector of read widths. This is required because compact sequence bytes use BAM's 4-bit packed encoding (two bases per byte).

Value

A character vector containing decoded sequence strings.

See Also

decode_compact_qual(), decode_seqqual_compact(), bam_read()

Examples

```
decode_compact_seq(
  seq = list(as.raw(c(0x12, 0x48))),
  qwidth = 4L
)
```

`decode_seqqual_compact` *Decode compact* `seq` *and* `qual` *columns in BamScale output*

Description

Convenience wrapper for converting a compact `bam_read()` result back to ordinary sequence and quality strings.

Usage

```
decode_seqqual_compact(
  x,
  seq_col = "seq",
  qual_col = "qual",
  qwidth_col = "qwidth"
)
```

Arguments

`x`	A `data.frame`, `S4Vectors::DataFrame`, or list-like object containing compact BamScale `seq` and/or `qual` columns.
`seq_col`	Name of the compact sequence column.
`qual_col`	Name of the compact quality column.
`qwidth_col`	Name of the read-width column used to decode compact sequence bytes.

Value

`x` with compact `seq` and/or `qual` columns replaced by decoded character vectors. The input class is preserved.

See Also

`decode_compact_seq()`, `decode_compact_qual()`, `bam_read()`

Examples

```
x <- data.frame(qwidth = 4L)
x$seq <- I(list(as.raw(c(0x12, 0x48))))
x$qual <- I(list(as.raw(c(0L, 1L, 2L, 3L))))
decode_seqqual_compact(x)
```

`fragment_sizes` *Fragment-size distribution, aggregated in C++*

Description

Computes the paired-end fragment-size (insert-size) distribution – a table of `abs(TLEN)` counts – by accumulating the histogram inside the multithreaded C++ reader, without ever materialising the per-read insert sizes as an R vector. This is the fast path for ATAC-seq / paired-end fragment-size QC on large BAMs: the histogram is folded together inside the OpenMP threads and only the compact `(fragment_size, count)` table crosses back into R (cf. `scanBam(what = "isize")` followed by `table(abs(isize))`, which materialises every insert size in R first).

Usage

```
fragment_sizes(
  file,
  param = NULL,
  threads = 1L,
  BPPARAM = BiocParallel::bpparam(),
  auto_threads = FALSE,
  max_fragment = 100000L,
  drop_mate_unmapped = TRUE
)
```

Arguments

`file`	A BAM file path, Rsamtools::BamFile, or a vector / `BamFileList` of them.
`param`	Optional Rsamtools::ScanBamParam (or a compatible list). Only its `flag` and `mapqFilter` are honoured, applied per read in C++ – e.g. `Rsamtools::ScanBamParam(flag = Rsamtools::scanBamFlag( isSecondaryAlignment = FALSE, isUnmappedQuery = FALSE, isNotPassingQualityControls = FALSE))` to reproduce the standard ATAC fragment-size filter.
`threads`	Number of OpenMP threads for within-file decoding.
`BPPARAM`	A BiocParallel::BiocParallelParam for across-file parallelism when `file` has more than one element.
`auto_threads`	Logical; if `TRUE`, balance the thread / worker split.
`max_fragment`	Integer; fragment sizes up to this value are tallied in a dense histogram and larger ones in an overflow map. Every observed size is returned exactly regardless of this value (default `1e5`).
`drop_mate_unmapped`	Logical; if `TRUE` (default), reads whose mate is unmapped (SAM flag `0x8`) are excluded – matching `Rsamtools::scanBam`, which reports their `isize` as `NA` (no defined template length), so that `table(abs(isize))` drops them. Set `FALSE` to tally `abs(TLEN)` over all flag-passing reads.

Value

A `data.frame` with columns `fragment_size` (integer `abs(TLEN)`) and `count` (numeric), one row per observed fragment size in ascending order. For multiple input files, a named list of such data.frames.

See Also

bam_read() for reading records, bam_count() for per-chromosome counts.

---

mapq_dist *Mapping-quality (MAPQ) distribution, aggregated in C++*

Description

Computes the MAPQ distribution – a table of per-value alignment-count – by accumulating the histogram inside the multithreaded C++ reader, without ever materialising the per-read MAPQ values as an R vector. This is the fast path for mapping-quality QC on large BAMs: each thread tallies MAPQ into a private 256-slot histogram inside the OpenMP region and only the compact `(mapq, count)` table crosses back into R (cf. `scanBam(what = "mapq")` followed by `table(mapq)`, which materialises every MAPQ in R first).

Usage

```
mapq_dist(
  file,
  param = NULL,
  threads = 1L,
  BPPARAM = BiocParallel::bpparam(),
  auto_threads = FALSE
)
```

Arguments

file	A BAM file path, Rsamtools::BamFile, or a vector / BamFileList of them.
param	Optional Rsamtools::ScanBamParam (or a compatible list). Only its flag and mapqFilter are honoured, applied per read in C++. Note that a non-zero mapqFilter removes reads below that MAPQ from the distribution.
threads	Number of OpenMP threads for within-file decoding.
BPPARAM	A BiocParallel::BiocParallelParam for across-file parallelism when file has more than one element.
auto_threads	Logical; if TRUE, balance the thread / worker split.

Value

A data.frame with columns mapq (integer, 0-255) and count (numeric), one row per observed MAPQ value in ascending order. For multiple input files, a named list of such data.frames.

See Also

fragment_sizes() for the fragment-size distribution, bam_count() for per-chromosome counts.

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