universalaccel (UA) Manual

Part 1: Generating Metrics • Part 2: Analysis & Interpretation

Contents

Abbreviations and Terms

- **UA** (*universalaccel*): the package ecosystem (functions + reference tables + output contracts).
- **ENMO** (*Euclidean Norm Minus One*): acceleration magnitude above 1g after removing the static component (autocalibration applied).
- **MAD** (*Mean Amplitude Deviation*): mean deviation of acceleration magnitude within an epoch.
- **AI** (*Activity Index*): variability-based activity metric computed from raw acceleration.
- **MIMS-unit** (*Monitor-Independent Movement Summary unit*): standardized activity summary intended to be comparable across devices.
- **ROCAM** (*Rate of Change Acceleration Movement*): change-based activity metric derived from successive acceleration movement samples.
- **AC** (*ActiGraph counts*): traditional "counts".
- **NHANES** (*National Health and Nutrition Examination Survey*): U.S. survey used here as the reference population for zone boundaries and percentile tables.
- **Anchor** (*Default metric scale for conditioning*): the metric context used to define zones and percentiles; other metrics can be **equated** onto this anchor via **equipercentile** mapping.
- **Epoch** (*Aggregation window*): the time length used to summarize raw samples into rows (e.g., 5 seconds or 60 seconds).
- **AA** (*Average acceleration/ Volume*): the daily time-weighted mean of the intensity distribution (computed from bin midpoints $\times$ minutes in bin).
- **IG** (*Intensity gradient*): the slope from regressing log(time in bin) on log(intensity midpoint); more negative means a steeper drop-off at higher intensities.

Part 1 — Generating Metrics (how to produce harmonized files)

1. What UA is (universalaccel)

universalaccel (UA) is an R pipeline for computing harmonized accelerometer summary metrics across multiple devices (Tested on: ActiGraph, Axivity, GENEActiv). The goal is to make raw accelerometer data comparable by producing standardized, epoch-level outputs with consistent naming, time handling, and reproducible settings.

UA tested files and order of operations:

- ActiGraph (GT3X), .gt3x raw data is passed through `?agcounts::agcalibrate()` first and metrics are computed.
- Axivity (AX3), .resampled.CSV is autocalibrated in OmGui, so metrics are directly computed.
- GeneActiv, .bin raw data is passed through `?GENEAread::recalibrate()` first and metrics are computed.
- Note that this workflow does not eliminate any file based on the threshold of calibration error.

2. Inputs and expectations (file formats, columns, epochs)

What you provide

Depending on device type, you provide: - Raw device files (ActiGraph `.gt3x`, Axivity `resampled`.csv, `GENEActiv`.bin‘)

Key expectations

- A consistent alignment ofmetric at the selected epoch length (`epoch_sec`; commonly 5 seconds or 60 seconds).
- Correct sample rate and dynamic range for raw devices as configured (or when required by some summary metrics).
- Consistent timezone handling (typically this is handled by device software but it is configurable here).

3. Quick Start: generate metrics with `?accel_summaries()` (epoch-level outputs)

```
# Run Part 1 metric generation.
# See more:?universalaccel::accel_summaries()
accel_summaries(
  device        = "actigraph", #define device type
  data_folder   = actigraph_path, # data folder for batch processing
  output_folder = output_dir, # output folder
  epochs        = 60,
  sample_rate   = 100,
  dynamic_range = c(-8, 8),
  metrics       = c("MIMS","ENMO","MAD","COUNTS","AI","ROCAM"),
  apply_nonwear = TRUE
)
#> Loading chunk: 1
#> ================================================
#> ================================
```

4. Output files and variable list (epoch-level metrics)

After running part 1, you will typically see one or more CSV files written to `output_folder`.

```
#> [1] "UA_actigraph_epoch60s_2026-01-08.csv"
```

time	MIMS_UNIT	MIMS_UNIT_X	MIMS_UNIT_Y	MIMS_UNIT_Z	ID
2023-06-13 08:34:00	25.76918	8.820309	7.123617	9.825254	example
2023-06-13 08:35:00	23.83363	11.807486	5.354003	6.672141	example
2023-06-13 08:36:00	21.47114	9.304060	5.745538	6.421537	example

Typical epoch-level variables (what they mean)

Exact columns depend on device and selected metrics, but commonly include:

- `time` (*timestamp*; start of the epoch)
- `ID` or `id` (*participant ID*; derived from file name or metadata)
- `epoch_sec` (*epoch length in seconds*)
- `ENMO` (*Euclidean Norm Minus One*)
- `MAD` (*Mean Amplitude Deviation*)
- `AI` (*Activity Index*)
- `MIMS_UNIT` (*Monitor-Independent Movement Summary unit*)
- `ROCAM` (*Rate of Change Acceleration Movement*)
- `Axis1`, `Axis2`, `Axis3` or `X`, `Y`, `Z` (*axis components*)
- `Vector.Magnitude` (*ActiGraph/Activity Counts*)
- `choi_nonwear` (*nonwear flag: epoch-aware*)

Part 2 — Analysis & Interpretation (precomputed files → distributions → zones → percentiles)

6. What "analysis-ready" means in UA

What you provide

Running this part necessitates pre-computed data of summary metric(s). Therefore, you provide:

- A pre-computed/processed table already aligned to an epoch and containing metric columns with age and sex columns.
- Note that the Second part is run on a file whose nonwear time was already removed (choi method was used when generating NHANES comparisons). Ideally one would pass UA part 1 outputs to part 2.

An "analysis-ready" UA file has:

- consistent time and epoch (`epoch_sec`)
- consistent metric naming (e.g., `enmo`, `mad`, `mims_unit`, `ac`)
- enough metadata to interpret results (age/sex when relevant; location label)

In UA, Part 2 analysis commonly produces:

- **daily distributions** (bins; minutes across intensity ranges)
- **zone summaries** (movement zones from NHANES references)
- **AA** (Average acceleration) and **IG** (Intensity gradient)
- **NHANES positioning** (percentiles and anchor-conditioned lookups)

7. Daily summaries and binned distributions (bins, zones)

Two common analysis constructs:

- **AA (Average acceleration/Volume):** the time-weighted mean intensity over the day.
- **IG (Intensity gradient):** the slope from regressing log(time-in-bin) on log(intensity-bin-midpoint).

Conceptually:

- Bins summarize *how much time* is accumulated in each intensity range.
- Zones group bins into interpretable "movement zones" based on normative boundaries.

8. NHANES references (National Health and Nutrition Examination Survey)

NHANES references provide:

- **normative zone boundaries** (per metric, epoch, NHANES age group, and sex when available)
- **normative percentiles** for AA (Average acceleration) and IG (Intensity gradient), by NHANES age ranges (e.g., Age 3–19 and Age 20–80)

UA uses NHANES references to answer:

- "Where does this person-day rank relative to a U.S. reference?"
- "What would other metrics look like at the same **anchor** percentile?" (anchor-conditioned lookup)

9. Quick Start (Part 2): run analysis on the bundled precomputed demo file

UA includes a small but "analysis-capable" precomputed demo file under:

`inst/extdata/Precomputed/UA_FLASH_sample.csv`

This demo is intentionally larger than the tiny raw samples (so AA, IG, and weekly rollups are meaningful).

Run Part 2 analysis

```
library(universalaccel)

analysis <- ua_analyze_precomputed(
  in_path     = pre_csv, # Specify where your dataset is at
  out_dir     = out_root,# Specify output directory
  location    = "ndw",
  make_weekly = TRUE,
  overwrite   = TRUE
)
```

10. Output tables (Output1–Output5) and variable lists

This manual assumes the Part 2 runner produces:

Output1 — Daily intensity distributions

Purpose: minute distribution across bins, with zone assignment.
Common variables:

- `id`, `day`, `epoch_sec`, `location`, `metric`
- `lower`, `upper`, `midpoint` (*bin boundaries*)
- `time_bin_min` (*minutes in bin*)
- `intensity distribution zones` (*zone labels*)

id	metric	bin_i	day	n	time_bin_min	lower	upper	midpoint
F3BA010	mims_unit	1	1	970	970	0.00000	12.28554	6.142769
F3BA010	mims_unit	2	1	193	193	12.28554	21.80029	17.042916
F3BA010	mims_unit	3	1	61	61	21.80029	24.82257	23.311432
F3BA010	mims_unit	4	1	38	38	24.82257	27.68250	26.252534
F3BA010	mims_unit	5	1	41	41	27.68250	30.48795	29.085227

Output2 — Distribution summary and metric conversions

Purpose: summarize minutes and intensity within zones; attach NHANES references.
Common variables:

- `minutes_in_zone` (*observed minutes*)
- `observed_intensity` (*observed time-weighted mean within zone*)

- `nhanes_anchor_*` (*NHANES reference metric whose scale was used to map/equate other summary metrics*)
- `equated_*` (*NHANES mean/SE for other metrics mapped onto the same anchor-zone definition*)

id	day	epoch_sec	location	metric	anchor	sex	age	category
F3BA010	1	60	ndw	ac	ac	F	18	Age-18-64
F3BA010	1	60	ndw	ac	ac	F	18	Age-18-64
F3BA010	1	60	ndw	ac	ac	F	18	Age-18-64
F3BA010	1	60	ndw	ac	ac	F	18	Age-18-64
F3BA010	1	60	ndw	ac	ac	F	18	Age-18-64

Output3 — Percentile positioning (Volume + IG), NHANES reference lookup

Purpose: (1) find your anchor percentile; (2) report NHANES values for other metrics at that same anchor percentile.
Common variables:

- `anchor_value_obs` (*observed Volume or IG for the anchor metric*)
- `anchor_nearest_centile` (*nearest NHANES centile for that value*)
- `nhanes_<m>_value_at_anchor_centile` (*NHANES value for metric m at that same centile under the same anchor panel*)
- `nhanes_<m>_centile_used` (*centile actually used; should match anchor centile unless snapped*)

id	day	epoch_sec	location	sex	age	age_range	anchor	stat
F3BA010	1	60	ndw	F	18	Age 3-19	ac	Intensity gradient
F3BA010	1	60	ndw	F	18	Age 3-19	ac	Volume
F3BA010	1	60	ndw	F	18	Age 3-19	enmo	Intensity gradient
F3BA010	1	60	ndw	F	18	Age 3-19	enmo	Volume
F3BA010	1	60	ndw	F	18	Age 3-19	mad	Intensity gradient

Output4 — Weekly summaries

Purpose: quick weekly averaging across days.
Common variables: - `week`, `n_days`, `overall_intensity_mean`, `ig_slope_mean`

id	metric	epoch_sec	location	sex	age	category	period_type	period_id
F3BA010	ac	60	ndw	F	18	Age-18-64	day	1
F3BA010	ac	60	ndw	F	18	Age-18-64	week	1
F3BA010	ai	60	ndw	F	18	Age-18-64	day	1
F3BA010	ai	60	ndw	F	18	Age-18-64	week	1
F3BA010	enmo	60	ndw	F	18	Age-18-64	day	1

Output5 — Run report (log)

Purpose: a plain-language summary of what ran, what was produced, and how to interpret the columns.

Reference

Part1 Implementation https://doi.org/10.1123/jmpb.2025-0024