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	ID	AI	Vector.Magnitude	ENMO	MAD	MIMS_UNIT
2023-06-13 08:34:00	example	19.788305	5389	106.8507	146.7423	25.76918
2023-06-13 08:35:00	example	22.495034	5161	160.8465	204.0852	23.83363
2023-06-13 08:36:00	example	9.880126	4799	143.8128	160.4939	21.47114

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	sex	age	metric	epoch_sec	bin_i	day	midpoint	time_bin_min	cm_time_min
F3BA010	F	18	mims_unit	60	1	1	6.142769	970	1399
F3BA010	F	18	mims_unit	60	2	1	17.042916	193	429
F3BA010	F	18	mims_unit	60	3	1	23.311432	61	236
F3BA010	F	18	mims_unit	60	4	1	26.252534	38	175
F3BA010	F	18	mims_unit	60	5	1	29.085227	41	137
F3BA010	F	18	mims_unit	60	6	1	31.863794	21	96
F3BA010	F	18	mims_unit	60	7	1	34.588930	17	75
F3BA010	F	18	mims_unit	60	8	1	37.261325	13	58
F3BA010	F	18	mims_unit	60	9	1	39.881663	9	45
F3BA010	F	18	mims_unit	60	10	1	42.450625	3	36

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	anchor	intensity_zone	observed_mean_intensity	nhanes_anchor_mean_nhanesw
F3BA010	ac	Volume	2684.52772	2416.71289
F3BA010	ac	Minimal	1082.64792	1082.64792
F3BA010	ac	Low-to-Moderate	3244.05266	3243.56133
F3BA010	ac	Moderate-to-High	4651.31149	4649.26663
F3BA010	ac	High-to-Very High	5733.47425	5811.17814
F3BA010	ac	Very High-to-Peak	8406.28566	8340.91321
F3BA010	ac	Peak	36406.35763	12758.77172
F3BA010	ai	Volume	83.29308	68.68406
F3BA010	ai	Minimal	33.85954	33.85954
F3BA010	ai	Low-to-Moderate	92.44820	92.44820

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	sex	age_range	anchor	stat	anchor_value_observed
F3BA010	1	F	Age 3-19	ac	Intensity gradient	-1.843593
F3BA010	1	F	Age 3-19	ac	Volume	2684.527720
F3BA010	1	F	Age 3-19	enmo	Intensity gradient	-1.338717
F3BA010	1	F	Age 3-19	enmo	Volume	46.685132
F3BA010	1	F	Age 3-19	mad	Intensity gradient	-1.646907
F3BA010	1	F	Age 3-19	mad	Volume	60.141793
F3BA010	1	F	Age 3-19	mims_unit	Intensity gradient	-1.979383
F3BA010	1	F	Age 3-19	mims_unit	Volume	14.260098
F3BA014	1	F	Age 3-19	ac	Intensity gradient	-2.880096
F3BA014	1	F	Age 3-19	ac	Volume	2024.214229

Output4 — Weekly summaries

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

id	metric	period_type	period_id	observed_total_minutes	observed_mean_intensity	observed_ig
F3BA010	ac	day	1	1399	2684.52772	-1.843593
F3BA010	ac	week	1	1399	2684.52772	-1.843593
F3BA010	ai	day	1	1399	83.29308	-1.959183
F3BA010	ai	week	1	1399	83.29308	-1.959183
F3BA010	enmo	day	1	1399	46.68513	-1.338717
F3BA010	enmo	week	1	1399	46.68513	-1.338717
F3BA010	mad	day	1	1399	60.14179	-1.646907
F3BA010	mad	week	1	1399	60.14179	-1.646907
F3BA010	mims_unit	day	1	1399	14.26010	-1.979383
F3BA010	mims_unit	week	1	1399	14.26010	-1.979383

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