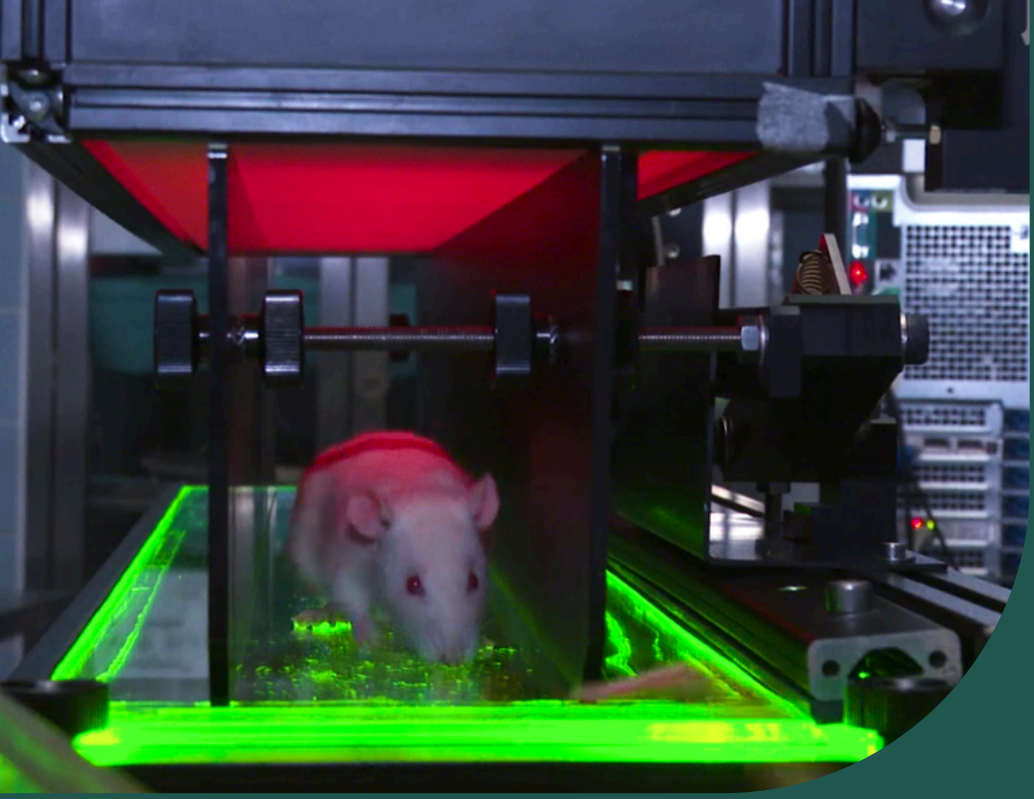


CatWalk 11

Technical specifications

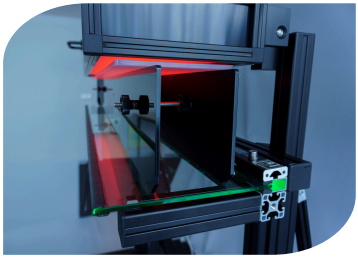
Automated gait analysis software for rodent research

NOLDUS

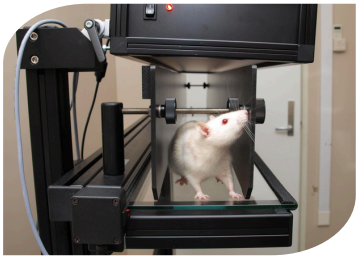
www.noldus.com/catwalk-xt

Principles of operation

CatWalk is an automated gait analysis system for rats and mice that uses Noldus's proprietary Illuminated Footprints™ technology to capture and quantify locomotor behavior with high precision. The system enables objective and reproducible assessment of gait, paw placement, and inter-limb coordination, making it suitable for both routine measurements and longitudinal studies in preclinical research.

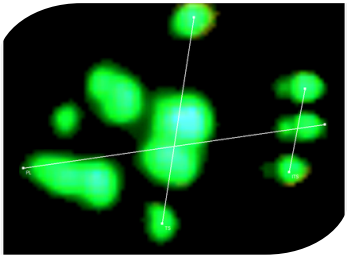


The apparatus consists of an enclosed walkway positioned on a glass plate. Green light enters through the long edge of the plate and is completely internally reflected within the glass. This light escapes only at the points where an animal's paws make contact with the surface, producing sharply defined illuminated footprints.



A high-speed camera mounted beneath the walkway records these footprints as the animal traverses the corridor. Following a short habituation period, animals can generally be encouraged to cross the walkway voluntarily, helping minimize handling-related stress and supporting the collection of natural gait patterns.

The captured video images are transferred to a computer via a 10 Gb Ethernet connection and analysed by the CatWalk software. The software extracts a wide range of gait parameters, allowing researchers to detect subtle changes in motor function in applications such as pain research, nerve injury, spinal cord injury, and neurodegenerative disease studies.



System configurations & licensing

License types

CatWalk 11.0 is available with either a hardware key (USB dongle) or a software license. Software licenses offer two modes:

- *Fixed license* — Tied to a single computer. Deactivation required before transferring to another machine. May be activated online or offline (via QR code).
- *Floating license* — Usable on multiple computers sequentially (not simultaneously). Requires internet connection on the acquisition computer. Multiple floating licenses allow simultaneous use.
- *Perpetual license* — One-time purchase; software may be used indefinitely.
- *Time-limited license* — Valid for a defined period (typically 6 or 12 months). Online activation only.

Analysis mode

CatWalk can be installed on additional computers without a license.

In unlicensed analysis mode, users can open experiments, classify runs, create data and parameter profiles, run all analysis functions, and export all data and statistics.

New data acquisition is not possible without a valid license.

Data management

Experimental setup

- *Animal Type* — Select Rat or Mouse. Determines the Automatic Footprint Classification algorithm and the Sciatic, Tibial, and Peroneal Functional Index formulas.
- *Time Points* — Define and label the time points at which data are acquired, with optional colour coding for group statistics.
- *Treatment Groups* — Define groups with type (Undefined, Experimental, Control, Sham), name, description, and display colour.
- *Run Criteria* — Set minimum and maximum run duration, minimum number of compliant runs to acquire, and an optional maximum allowed speed variation threshold. Runs not meeting criteria are marked non-compliant; acquisition continues until the required number of compliant runs is reached.
- *Trial List* — Pre-plan trials with animal ID, time point, group assignment, and optional description. Trial names are unique identifiers. The list shows acquisition status, total runs, compliant runs, and classification status for each trial.
- *Experiment Setup Profiles* — Save and reuse a set of experiment settings (time points, treatment groups, trial structure) across new experiments.
- *Preferences* — Distance unit (millimetres, centimetres, or inches), decimal precision for numbers, times and percentages; folder locations; auto-save interval; paw display colours.

File management

- *Experiment files* — Stored as *.cwe files within a named experiment folder.
- *Backup and restore* — Experiments can be backed up to *.cwz archives and restored from them. Auto-save at configurable intervals (default: every 5 minutes).
- *Backward compatibility* — CatWalk 11 opens and converts experiments from versions 8.x, 9.x, 10.x. Experiments from versions prior to 11 are read-only (analysis only; no new acquisition). Experiments from versions 7.x or earlier cannot be opened.

Walkway setup

Setup workflow

Setting up the walkway involves three sequential steps, each supported by a dedicated tool:

- *Focus Assist* — Interactive tool to focus the camera lens. A sharpness indicator (percentage of maximum reachable sharpness) guides the user. A bottom-image view highlights sharp areas for real-time feedback.
- *Automatic Walkway Calibration* — After focusing, a dedicated calibration card placed in the walkway is detected automatically. Calibration converts pixel dimensions to real-world units (mm/pixel). Manual calibration is possible but not recommended.
- *Automatic Walkway Definition* — The software automatically detects the corridor walls and defines a walkway rectangle covering 70% of the walkway length. The walkway can be resized and repositioned manually. A Validate Walkway function checks corridor-wall alignment at the start of each acquisition session.

Once set up, the walkway configuration is retained across sessions. Re-setup is only required if hardware is changed (e.g., camera position, corridor width).

Detection settings

- *Auto Detection* — With an animal on the walkway, CatWalk automatically adjusts Camera Gain and Green Intensity Threshold to achieve optimal paw-print intensity (target: Maximum Green Intensity 197–203). Default Detection Settings profiles for Rats and Mice are provided.
- *Manual Detection* — Camera Gain and Green Intensity Threshold can be fine-tuned manually. The intensity of the Green Walkway Light and Red Ceiling Light can also be adjusted.
- *Camera Gain* — Controls Maximum Green Intensity of detected prints. Optimal range: 5–12 dB.
- *Green Intensity Threshold* — Sets the minimum pixel intensity for paw detection. Removes background noise. Can also be adjusted per run in the Classification screen before classification.

Data acquisition

Acquisition procedure

After snapping a background image of the empty walkway, the user clicks Start Acquisition. CatWalk automatically detects when the animal enters the camera view and begins recording.

A run stops automatically when the animal leaves the field of view.

Acquisition settings

- *Auto-abort* — Runs can be automatically aborted if they exceed a set duration. Runs are always stopped at 60 seconds maximum.
- *Discard options* — Separately configure whether auto-aborted runs, user-aborted runs, non-compliant runs, and incomplete prints at walkway borders are discarded automatically.
- *Sound feedback* — Auditory beeps (1 = run started, 2 = run stopped, 3 = error) can be enabled or disabled.

Acquired runs list

For each run, the following variables are displayed:

- Run number
- Start date and time
- Duration
- Compliance status (with reason if non-compliant)
- Walking direction
- Run average speed
- Run maximum speed variation,
- Camera gain
- Green intensity threshold

Run classification

Paw print classification

- *Manual Classification* — Users draw boxes around prints and assign labels: Right Front (RF), Left Front (LF), Right Hind (RH), Left Hind (LH), Right Hip (RM), Right Knee (RK), Left Hip (LM), Left Knee (LK), Nose (NO), Abdomen (AB), Tail (TA), Genitalia (GT). Grouping boxes around labeled and unlabeled prints of the same paw speeds up labeling.
- *Automatic Footprint Classification (AFC)* — Optional add-on module. Uses the body contour of the animal to automatically assign paw labels. AFC works best with a clean glass plate, straight uninterrupted runs, and an animal that contacts the glass only with its paws. Manual pre-labeling of non-paw prints before running AFC is recommended. A minimum Max Intensity threshold can be set to filter noise.
- *Green Intensity Threshold (per run)* — Can be adjusted before classification to fine-tune paw detection without affecting other runs.

Classification views

- *Print View* — Displays all paw prints in 2D. Available in Normal Color, False Color (intensity gradient green–red), and Colorized modes. Prints can be shown all-at-once or per frame.
- *Timing View* — Time-based gait diagram. Bars represent stance duration per paw; gaps represent swing. Clicking a bar jumps to the corresponding video frame.
- *Numerical Results* — Per-print table with initial contact time, stand duration, max contact time and area, max and mean intensity, print length, width and area.

Error correction

- *Labeling errors* — Reset and re-assign labels using the Print View or Timing View as guides.
- *CatWalk errors* — Detected automatically when the same label is assigned to two paws in the same frame. Listed in the Video section for correction.
- *Print errors* — Noise or non-paw body parts included in a paw rectangle can be corrected by removing and re-adding prints.
- *Combine stances* — Two sub-divided stances of the same paw can be manually combined.

Interactive footprint measurements

This optional Interactive footprint measurement (IFM) module is used for detailed toe measurements on hind paws to calculate functional nerve recovery indices.

- *Toe Spread (TS)* — Distance between the centre of the first and fifth toe.
- *Intermediate Toe Spread (ITS)* — Distance between the centre of the second and fourth toe.
- *Manual Print Length (PL)* — Distance from the centre of the third toe to the heel.
- *Paw Angle Body Axis* — Smallest angle between the Print Length line and the body axis.
- *Paw Angle Movement Vector* — Smallest angle between the Print Length line and the calculated movement direction (linear regression over four consecutive body-contour positions).

Data selection

Data segmentation profiles

A Data Segmentation profile selects the portion of each classified run that meets three criteria: minimum number of consecutive steps, average speed range, and maximum allowed speed variation.

Multiple profiles can be created and saved; the default All Data profile includes all classified steps.

- *Minimum number of consecutive steps* — recommended ≥ 10 (ensures each paw is placed at least twice, enabling calculation of stride-based parameters).
- *Average speed range* — set in distance units per second.
- *Maximum allowed speed variation* — expressed as percentage deviation from run average speed.
- Options to exclude non-compliant runs and/or partially classified runs.

The Selected Data Overview shows the proportion of animals, runs, and steps selected per group and time point.

Parameter profiles

Parameter profiles allow selection of specific paws and parameters for display in Run Statistics, Group Statistics, and export files. The default All Parameters profile cannot be edited or deleted.

Analysis Parameters - Dependent variables

Paw statistics

Parameter	Description
Temporal - Contact	
Initial contact at (s)	Time since run start when a paw first contacts the glass plate
Stand / Stance (s)	Duration of contact of a paw with the glass plate
Stand Index	Rate at which the paw loses contact with the glass plate (negative value; more negative = faster lift). Requires ≥ 5 frames of stance.
Max contact at (s)	Time since run start at which the paw reaches maximum contact area (transition from braking to propulsion phase).
Max contact at (%)	Max Contact At expressed as a percentage of stance duration.
Spatial - Contact area & intensity	
Max Contact Area	Surface area of the paw print at Max Contact At.
Max Contact Max Intensity	Maximum pixel intensity of the print at Max Contact (range 0–255; proxy for weight-bearing).
Max Contact Mean Intensity	Mean pixel intensity of the print at Max Contact.
X position	Horizontal position of the paw print centre at Max Contact.
Y position	Vertical position of the paw print centre at Max Contact.
Print Length	Length (horizontal / walking direction) of the complete print.
Print Width	Width (perpendicular to walking direction) of the complete print.
Print Area	Surface area of the complete print (all stance frames combined; ≥ Max Contact Area).
Max Contact Area	Surface area of the paw print at Max Contact At.
Temporal - Intensity	
Max intensity at (s)	Time since run start at which maximum print intensity occurs.
Max Intensity At (%)	Max Intensity At expressed as a percentage of stance duration.
Max Intensity	Maximum intensity of the complete paw print across all stance frames.
Min Intensity	Minimum intensity of the complete paw print.
Mean Intensity	Mean intensity of the complete paw print.
Mean Intensity of 15 Most Intense Pixels	Mean intensity of the 15 highest-intensity pixels of the print.
Swing & Stride	
Swing (s)	Duration of no contact with the glass plate between two stances.
Swing speed	Speed of the paw during swing (Stride Length / Swing).
Stride length	Distance between successive placements of the same paw (centre-to-centre at Max Contact).
Step Cycle (s)	Time between two consecutive Initial Contacts of the same paw (Stand + Swing).
Duty Cycle (%)	Stand expressed as a percentage of Step Cycle.

Analysis Parameters - Dependent variables

Paw statistics - continued

Parameter	Description
Body dynamics	
Initial contact at (s)	Body Speed
Stand / Stance (s)	Body Speed Variation (%)
Dual / Single stance (hind paws)	
Single Stance	Duration during which only one hind paw contacts the glass plate (contralateral hind paw off ground).
Initial Dual Stance	First period in a hind-paw step cycle during which both hind paws simultaneously contact the glass.
Terminal Dual Stance	Second period in a hind-paw step cycle during which both hind paws simultaneously contact the glass.
Interactive hind paw footprint measurement (module)	
Max intensity at (s)	Time since run start at which maximum print intensity occurs.
Max Intensity At (%)	Max Intensity At expressed as a percentage of stance duration.
Max Intensity	Time since run start at which maximum print intensity occurs.
Min Intensity	Max Intensity At expressed as a percentage of stance duration.
Mean Intensity	Time since run start at which maximum print intensity occurs.
Mean Intensity of 15 Most Intense Pixels	Mean intensity of the 15 highest-intensity pixels of the print.

Step sequence

Parameter	Description
Regularity Index (%)	Number of Normal Step Sequence Patterns (NSSP) × 4 / Total paw placements × 100%. Value of 100% indicates fully coordinated gait. Used in spinal cord injury research.
Footfall Patterns	Six recognised pattern families: Cruciate A (CA), Cruciate B (CB), Alternate A (AA), Alternate B (AB), Rotate A (RA), Rotate B (RB). Labelling is independent of which paw starts the run.
Normal Patterns	Count of step cycles falling within one of the six recognised footfall pattern categories.
Accounted Steps	Total number of steps used to determine footfall patterns.

Base of support

Parameter	Description
Base of Support — Front Paws	Mean Y-axis distance between the centres of the two front paws at Max Contact.
Base of Support — Hind Paws	Mean Y-axis distance between the centres of the two hind paws at Max Contact.

Analysis Parameters - Dependent variables

Print positions

Parameter	Description
Print positions	Distance between the ipsilateral front and hind paw in the same step cycle (X-axis at Max Contact). Positive = hind paw behind front paw; negative = hind paw in front of front paw.

Other statistics

Parameter	Description
Duration	Duration of the run based on selected steps (Data Segmentation profile).
Average Speed	Average speed of selected steps (distance units/second).
Maximum Variation (%)	Maximum variation in average speed within the selected steps.
Cadence	Steps per second, calculated from Initial Contact of the first to last selected step.
Number of Steps	Total number of selected steps.
Sciatic Functional Index (SFI)	Functional recovery measure for the sciatic nerve. Uses Manual Print Length, Toe Spread, and Intermediate Toe Spread for experimental vs. normal contralateral hind paw. Calculated separately for rats (Bain 1989) and mice (Inserra 1998). Requires IFM module.
Posterior Tibial Functional Index (TFI)	Recovery measure for the tibial nerve branch. Same inputs as SFI. Requires IFM module.
Peroneal Functional Index (PFI)	Recovery measure for the peroneal nerve branch. Uses Print Length and Toe Spread. Requires IFM module.

Phase dispersions

Phase Dispersions describe the temporal relationship between the placement of two paws within a step cycle, expressed as a percentage of the anchor paw's step cycle time. Six paw-pair combinations are reported. Range: –50% to +50% (CStat Mean). Values are circular statistics.

Parameter	Description
Diagonal pairs	RF–LH and LF–RH (anchor = front paw).
Girdle pairs	LF–RF and LH–RH (anchor = left paw).
Ipsilateral pairs	RF–RH and LF–LH (anchor = front paw).
CStat Mean (%)	Circular mean of phase dispersions (range –50% to +50%).
AD (Angular Deviation)	Measure of spread around the mean (equivalent to Standard Deviation in CatWalk ≤ 10.6).
SD (Circular Standard Deviation)	Alternative spread measure; ranges from 0 to ∞.
R	Length of the mean vector (0–1); higher R = greater consistency of inter-paw timing across step cycles.
Mismatches	Count of ANT (anchor, no target), AMT (anchor, multiple targets), and TNA (target, no anchor) occurrences.

Analysis Parameters - Dependent variables

Couplings

Couplings are computed the same way as Phase Dispersions but a target can never precede its anchor; values range from 0% to 100% (CStat Mean). Twelve paw-pair combinations are reported. The same statistics (CStat Mean, AD, SD, R, Mismatches) are available as for Phase Dispersions.

Parameter	Description
Support Formula	Number of paws simultaneously on the glass plate in each section of a step cycle (e.g., 2–3–2–3–2–3–2–3).
Footfall Formula	Alphanumeric notation indicating which specific paws are on the glass plate during each section.
Standing on %	Relative duration of simultaneous contact for all combinations: zero, single, diagonal, lateral, girdle, three, and four paws.

Group statistics

Group statistics aggregate per-trial values by treatment group and time point combination. Available statistics: N, Mean (arithmetic or circular), SEM, CStat Mean, CStat R, CStat AD, CStat SD.

Charts: Bar chart (mean ± SEM) or Five Number Summary (box-whisker, minimum 4 trials required). Circular charts for Phase Dispersions and Couplings. Charts can be split by treatment group, time point, or both.

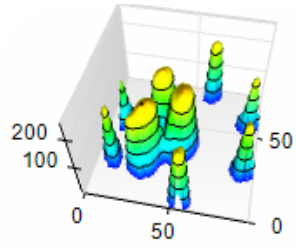
Research applications

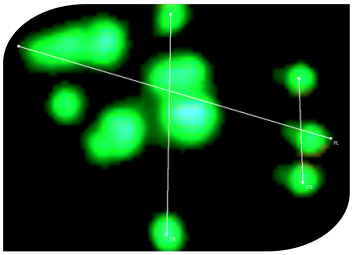
CatWalk has been validated and applied extensively across a wide range of preclinical research areas. The following disease models and research areas have been studied using CatWalk gait parameters.

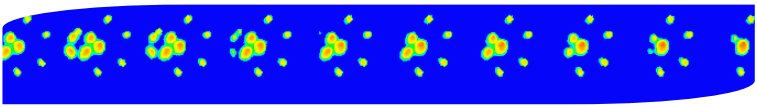
Research area	Commonly affected parameters
Spinal cord injury	Base of Support, Intensity, Stand, Phase Dispersions, Regularity Index, Stride Length
Neuropathic pain	Print Area, Intensity, Duty Cycle, Swing Duration, Swing Speed
Ischemia / Stroke	Swing Speed, Intensity, Duty Cycle, Phase Dispersions, Regularity Index, Stride Length
Amyotrophic Lateral Sclerosis	Stand, Stride Length, Duty Cycle, Support on diagonal and 3 limbs
Cerebellar ataxia	Swing & Stand Duration, Regularity Index, Print Area, Stride Length, Phase Dispersion
Motor coordination (cerebellar cortex)	Stride Length, Duty Cycle, Swing Speed, Phase Dispersions, Support formulas
Parkinson's disease models	Average Speed, Regularity Index, Print Area, Swing Speed, Stride Length, Stand Index
Sciatic nerve injury	SFI, Paw Print Intensities, Couplings, Base of Support, Stride Length
Arthritis (mono- and osteoarthritis)	Print Area, Mean Intensity, Duty Cycle, Regularity Index
Huntington's disease	Swing Speed, Stand
Charcot-Marie-Tooth disease	Print Length/Width, Max Contact Area, Max Intensity, Couplings
Genetic / toxic models (Refsum, Leigh)	Print Area, Swing Speed, Stride Length, Stand Index, Regularity Index

Visualizations

- *3D Footprint Intensities* — Plots paw print intensity values (0–255) per video frame as a rotating 3D chart. Uses the same false-colour scale as the Classification Print View.
- *2D Footprint Intensities* — Plots maximum and mean intensity for each paw print over time in a 2D chart. A vertical hairline marks the current video position.
- *Footfall Patterns diagram* — Graphical representation of the order in which paws were placed. Dots are colour-coded: blue = start of pattern, green = within pattern, orange = not counted, purple = not part of a recognised pattern.







Output and export

Export formats

Export Type	Format	Content
Run Data	Excel (.xlsx)	Raw print data per video frame (100 frames/s): X/Y position, print dimensions, min/max/mean intensity — per paw, per frame.
Run Statistics	Excel (.xlsx)	Summary statistics per run (one row per run). Selectable parameter categories and statistics (mean, SD).
Trial Statistics	Excel (.xlsx)	Combined statistics across all runs in a trial (one row per trial). Weighted averages.
Group Statistics	Excel (.xlsx)	Statistics per treatment group × time point combination (one sheet per parameter group).
Group Charts	PDF	All charts in Graphical Results exported to a single PDF file. Individual charts: PNG.
Run Visualizations	AVI (uncompressed)	3D/2D Footprint Intensities and Footfall Patterns exported as video at selectable playback speed. No codec required.
Run Video	AVI (uncompressed)	Raw run video with optional overlay of labels, rectangles, and time/frame information.

All exports include metadata columns: Experiment, Group, Group Type, Group Description, Animal ID, Time Point, Trial, Run, walkway dimensions, pixel calibration values, Camera Gain, and Green Intensity Threshold. Units are included in all parameter labels as of CatWalk 11.

Hardware and system requirements

Minimum set-up

- CatWalk 11 software with valid license
- CatWalk system hardware (walkway, glass plate, green LED illumination, illuminated ceiling with red LEDs, CatWalk Control Unit)
- Basler high-speed camera (1920 × 1216 pixels, pre-configured)
- Computer with USB-C port (for Control Unit connection) and 10 Gb Ethernet PCIe card (for camera connection)

Optional components

- Goal box (to motivate the animal to cross the walkway)
- Noldus goal box with sliding door
- Diffusion plate (fits on top of corridor walls to prevent rearing)
- Calibration card (included with CatWalk 11)

Camera specifications

Type	Brand / Model	Interface	Connection	Frame Rate
GigE	Basler (10 GigE)	Basler Pylon Runtime	10 Gb Ethernet PCIe card	100 fps

CatWalk control unit

- Connected to the walkway, camera, and illuminated ceiling.
- Connected to the CatWalk computer via USB-C cable (requires a USB-C port on the computer).
- Controls green walkway LED light (adjustable voltage) and red ceiling LED light (adjustable voltage).
- Firmware upgradeable from within CatWalk software.

System requirements

Operating system

- Windows 10 Pro, version 22H2 or later
- Windows 11 Pro

Administrator rights required for installation. Do not run CatWalk for the first time as an administrator on a multi-user computer.

Recommended computer configuration

Tested System	Dell Precision T3660
Processor (CPU)	Intel Core i7-11700, 8-core, 2.5–4.9 GHz, 16 MB cache
Memory (RAM)	16 GB DDR5 (minimum requirement)
Primary hard disk	M.2 256 GB PCIe NVMe SSD
Secondary hard disk	3.5-inch 1 TB SATA (7200 rpm) for experiment storage
Graphics card (GPU)	NVIDIA Quadro T1000, 4 GB
USB port	USB-C (required for Control Unit connection)
Network interface	10 Gb Ethernet PCIe card (required for camera connection; included if ordering computer from Noldus)

Camera connection

- A dedicated 10 Gb (gigabit) Ethernet PCIe network interface card is required for connecting the digital camera.
- Driver installation is included in the CatWalk 11 installer.
- Basler Pylon Runtime is included in the CatWalk 11 installer (replaces the legacy Pleora eBUS driver of previous versions).
- After starting the computer and turning on the Control Unit, allow approximately 1–2 minutes for the camera to be detected.

Help features

- *PDF Reference Manual* — The complete CatWalk 11.0 Reference Manual is accessible from the Help menu (F1).
- *Tutorial videos* — Video tutorials are installed on the computer and accessible from the Help menu.
- *Quick Start Guide* — Step-by-step guide for setting up, acquiring, and analysing a first experiment.
- *Assembly Instructions* — Separate document for assembling the CatWalk hardware and goal box.
- *Sample Experiments* — Three sample experiments (with mouse and rat data) are provided. Accessible via File > Restore Backup.
- *Noldus Help Desk* — 24-hour support across multiple time zones. Contact via my.noldus.com. PC report utility available on request.
- *Online Knowledge base* — Searchable database of customer questions and support answers at my.noldus.com. This knowledge base is supported by our online chatbot which can help you find the answers you need to frequently asked questions.

For more information or contact please contact your local account manager of visit our website

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