Control strategies for daylight and artificial lighting in office buildings – A bibliometrically assisted review

Additional Data: Items - Keyword Groups and Research References

June 25, 2021

VOSviewer was used to list all keywords in all relevant research articles. The elements of this list have then been grouped and every group was associated with a meaningful term. These terms are referred to as items in the review article, following the nomenclature in the VOSviewer literature. The following table shows all items and the corresponding group of keywords.

Items	**Keyword Groups**
(smart) commissioning	plug-and-play control, calibration, commissioning, implementation, plug-and-play systems, real-time implementation, self-commissioning, sensor calibration

building energy savings	building electricity consumption, building energy, building energy conservation, building energy consumption, building energy efficiency, building energy management, building energy performance, building energy-efficiency, building global energy performance, building optimization, building performance, consumption, electricity demand reductions, energy, energy audit, energy benchmarking, energy conservation, energy consumption, energy demand, energy efficiency, energy efficient buildings, energy optimization, energy performance, energy performance of buildings, energy reduction of buildings, energy saving, energy saving measures, energy savings, energy use, energy use intensity, energy-efficiency, energy-efficiency policy measures, energy-efficient buildings, energy-savings, green building, green buildings, green ict, life cycle energy, low energy building, low exergy building systems, net zero energy building, net-zero energy buildings, nzeb, passivhaus, positive-energy buildings, potential electricity savings, potential energy saving, potential energy saving estimation, smart building energy management, smart buildings,scheduling and optimization,power, smart energy buildings, zero energy building, zero energy buildings, zero net energy buildings, zero-energy buildings
building energy simulation	bems, building controls virtual test bed (bcvtb), building dynamic model, building energy model, building energy modeling, building energy prediction, building energy simulation, building envelope model, building modeling, building modelling, building performance modeling, building performance simulation, building simulation, building thermal and airflow modeling, computer simulation, computer simulations, co-simulation, co-simulations, energy consumption model, energy forecasting, energy model, energy performance prediction, energy saving, bems, energy simulation, energyplus, environmental simulation, equation-based modeling, hourly simulation, hvac models, hygrothermal model, integrated building simulation, integrated simulation, jeplus, modelica, multi-physics simulation, multi-zone building model, multi-zone modelling, simple bems, thermal model, trnsys, weather data file generation

building skin	adaptive building envelope, building envelope, building skin, embodied energy, envelope, façade configurations, facade technologies, facades, formchanging materials, g-value, high performance building envelopes, high-performance envelopes, intelligent building envelopes, intelligent façade, kinetic architecture, kinetic building skins, kinetic facade, kinetic facades, low-e window, rammed earth, responsive architecture, responsive building elements, responsive facade systems, roof windows, shgc, skin façade proportions, u-value, window, window design, windows
centralized control	central energy management system, centralized and distributed lighting control, control of terminal systems, supervisory control
CFS	adaptive façade, adaptive façades, complex fenestration systems, complex fenestration systems (cfs), directionally selective shading, dynamic faades, dynamic facade, dynamic façade, dynamic facades, dynamic façades, dynamic shades, dynamic shading, dynamic solar shading, dynamic window, elechtrochromic glazing (ec), electrochromic, electrochromic glazing, kinetic cladding components, photochromic, smart glazing, smart window, thermochromic
comfort	adaptive comfort, collaborative comfort management, comfort, controls acceptance, dissatisfaction, emotion, environmental design, environmental performance, environmental satisfaction, indoor comfort, occupant comfort, occupant complaints, occupant satisfaction, occupant's comfort, satisfaction, time delay, user acceptance, user behaviour, user comfort, user experience, user satisfaction
daylight availability	daylight availability, daylight availability assessment, daylight estimation, daylight factor, daylight harvesting, daylight illuminance, daylight maximization, daylighting design, daylighting performance, udi, useful daylight illuminance (udi), useful daylight illuminances
daylight control	advanced daylighting systems, advanced façades, automated blind, automated blind control, automated blinds, automated roller shade systems, automated shading, automatic roller-blinds, bidirectional scattering distribution functions bs, climate-based daylighting, daylight control system, daylight responsive dimming system, daylight responsive dimming systems, daylight responsive lighting control system, occupancy and daylight adaptation, shading control, shading control strategy, shading design and control

decentralized control	decentralized control, abstract–decentralized control systems have, autonomous distributed control, decentralised control, decentralized, decentralized control, decentralized control systems have, distributed control, distributed convex programming, distributed generation, distributed lighting control, distributed lighting systems, distributed optimization, distributed sensing, distributed sensing and light actuation, distributed wireless, independent control, multi-agent control, multi-agent control system, multi-agent system, multi-agent systems, multiagent systems (mas), multi-agent systems (mas), multiple actuators
DRC	heliostatic systems, holographic optical elements, laminated glass, light pipes, light-pipe, lightshelf, reflective louvre
energy efficient control	building energy management system, building energy management system data, building energy management systems, building energy management systems (bems), building energy system, building energy system optimization, dynamic energy consumption, en 15232 standard, energy and control effectiveness, energy efficiency control accuracy user thermal de, energy hub, energy management, energy management controller, energy management system, energy management systems, energy saving system
experimental validation	data measurement, experimental validation, field data, field measurement, field study, field test, field testing, monitoring, monitoring campaign, monitoring study, on-site monitoring, post-occupancy evaluation, real-time experiments, testbeds
glare	daylight glare, day-light glare index, daylight glare index (dgi), daylight glare probability, dgi, discomfort glare, glare, glare control, glare index, luminance
hvac control	autonomous thermostat control, building climate control, demand-controlled ventilation, dynamic temperature setpoint, efficient climate control, heat emitter control, heating consumption prediction, hvac control, hvac control for low-energy buildings, hvac control review, hvac predictive control, hvac supervisory control, load balancing, load management, mean radiant temperature, multi-zone environment control, occupancy based building climate control, occupancy-based zone-climate control, setback temperature restoration period artificial, set-back thermostat, smart heating control, smart hvac operation, smart thermostats, supply air temperature control, temperature control, temperature control models, thermal comfort control

hvac energy	building thermal load, cooling demand, cooling energy, cooling load, cooling load uncertainty, energy efficient building climate, heating, heating and cooling loads, heating demand, heating load, hvac efficiency, hvac energy, hvac energy optimization, low temperature heating, low-energy cooling
learning system	ann, ann-imc closed loop control, artificial intelligence, artificial neural network, artificial neural network (ann), artificial neural networks, artificial neural networks (anns), batch reinforcement learning, bayesian learning, bayesian network, bayesian networks, children, continuous improvement, deep reinforcement learning, elm (extreme learning machine), evolutionary algorithms, extended kalman filter (ekf), gaussian mixture model (gmm), gaussian regression, general regression neural network, genetic algorithm, genetic algorithm (ga), genetic algorithms, genetic tuning, influence diagrams, iterative optimization, kalman filter, kalman tracking, k-nearest neighbors, learning, learning controls, machine learning, metaheuristic optimization, metaheuristic search algorithms, nearest neighbor method, neural network, neural networks, neural networks ensemble, nnarx, nsga, nsga-ii, on-line learning, on-line training, particle swarm optimization, particle swarm optimization (pso), probabilistic methods, probabilistic models, pso, q-learning, radial basis function neural networks, radial basis neural network., random forest (rf), rbf neural network, reinforcement learning, reinforcement learning (rl), reinforcement learning control, support vector machine (svm)
light simulation	daylight modelling, daylight simulation, daylighting analysis, diva, illuminance estimation, lighting simulation, lighting simulation program, radiance, radiance software, radiosity method, ray-tracing, relux simulation

lighting control	adaptive illumination control, adaptive lighting systems, daylight-adaptive lighting control, daylight-linked control systems, daylight-linked controls, daylight-linked dimming, daylight-linked lighting controls, daylight-linked system, daytime lighting, dimming, dimming control, dimming control system, dimming controls, feedback control of lighting systems, functional illumination, high frequency dimming controls, illumination control, illumination control of led based lighting systems, inside illuminance control, intelligent lighting, intelligent lighting control, intelligent lighting system, intelligent lighting systems, light control, light direction, light spectrum control, lighting control, lighting control architectures and methods, lighting control strategies, lighting control system, lighting control systems, lighting control visual comfort energy-saving offi, lighting controls, lighting design, lighting system, minimum light intensity control, networked illumination control, networked lighting, on-off controls, optimal illumination control, photocontrolled lighting, photocontrolled lighting systems, smart light control system, smart lighting, smart lighting control
lighting energy	electric lighting consumption, energy efficient lighting, energy-efficient lamps, energy-efficient light control, energy-efficient lighting systems, energy-saving lighting, leni, light-energy consumption, lighting consumption, lighting consumption in office buildings, lighting energy, lighting energy demand, lighting energy savings, lighting energy use, lighting heat, lighting level, lighting performance, luminance efficiency
lighting sensors	illuminance measurement, incident irradiance, light sensing, light sensor calibration, light sensor fusion, light sensors, light-harvesting sensors, optical sensor, photometry, photosensor, sky luminance mapping, solar tracking, spectral response, spectral sensing

multi objective control	comfort and energy efficiency, cooperation, daylight and occupancy adaptation, daylight and occupancy adaptive lighting, daylight integrated illumination, energy-comfort optimization, integrated control, integrated daylighting system, integrated design, integrated energy system modelling, integrated systems, interdisciplinary collaboration, interoperability, interworking, multi-criteria optimization, multi-objective context-adaptive, multi-objective evolutionary algorithms, multi-objective genetic algorithm, multi-objective optimization, networked control systems, optimal lighting and daylight-based lighting contr, shading and lighting control systems
occupancy detection	activity recognition, chair sensors, human motion detection, human motion tracking, indoor granular presence sensing, indoor location, indoor positioning, indoor positioning,building usage information maps, location-aware, motion sensor, multiple target tracking, occupancy, occupancy detection, occupancy detection system, occupancy information, occupancy measurement, occupancy rate, occupancy sensing, occupancy sensor, occupancy sensors, occupant density, occupants, photoelectric, photoelectric controls, pir, presence and light sensing, presence and light sensors, presence sensing, real-time occupancy detection, room activities, wifi-based occupancy sensing
occupancy modeling	adaptive occupant behaviors, behavioral modeling, behavioral pattern, behaviour, behavioural change, behavioural modelling, daily occupancy, occupancy behavior patterns, occupancy estimations, occupancy learning, occupancy modeling, occupancy models, occupancy patterns, occupancy prediction, occupancy schedule, occupancy spread, occupancy strategy, occupant behavior, occupant behavior modeling, occupant behaviour, occupant behaviour in buildings, occupant learning, occupants behavior, occupants' presence model, scheduling

predictive control	anticipative energy management, cyber-physical system, cyber-physical systems (cps), feedforward, feed-forward control, markov chain, markov chains, markov decision problems, markov model, markov processes, model predictive control, model predictive control (mpc), model-based and predictive control, model-based control, model-based predictive control, model-predictive control (mpc), mpc, prediction time horizon, predictive accuracy, predictive building systems control, predictive control, predictive control for nonlinear systems, predictive models, sarsa algorithm, stochastic model predictive control, weather forecasting, wiener model
rule based control	adaptive fuzzy logic, case based reasoning, case-based reasoning, closed-loop identification, closedloop nonlinear approach, control scheme, event-triggered mechanism, feedback control, fuzzy, fuzzy control, fuzzy controller, fuzzy inference system, fuzzy logic, fuzzy logic controller, fuzzy logic controllers, fuzzy model, fuzzy model reference adaptive system (fmras) cont, fuzzy pid, fuzzy rough set, hybrid pidfuzzy, occupancy controls, office occupancy control, pi control, pi controllers, pid controller, robust control, rule selection, rule sets, sense and respond
shading system	adaptive shading daylighting system, angular dependent properties, angular selective systems, blind, blind control, blind operation survey, blind tilt angle, blinds, brise soleil, exterior shades, external blind, external shading, external venetian blinds, internal blind, internal blinds, louver, louvers, manual blind, manual blind control, motorized blind, movable roller blind, movable systems, multiple blinds, photocontrolled blinds, roller blinds, roller shades, shading, shading device, shading devices, shading system, shading systems, shading-type building-integrated photovoltaic clad, slat-type blind, solar shading, solar-control coating, venetian blind, venetian blinds, venetian shading, window blinds
smart building	adaptive home/building energy management system us, building and facility automation, building automation, building automation system, building automation systems, building management systems, building management systems (bmss), home and building automation, home automation, home networks, intelligent building, intelligent buildings, intelligent house energy management, smart building, smart building grid, smart buildings, smart home

thermal comfort	actual mean vote, actual mean vote (amv), adaptive thermal comfort, dynamic thermal sensation, dynamic thermal sensation (dts), human thermal comfort, indoor thermal comfort, pmv, pmv index, predicted mean vote, predicted mean vote (pmv) index, thermal comfort, thermal perception, thermal pleasure, thermal sensing, thermal-comfort, thermoreceptors
user-centered	human factor, human factors, human interaction, human-building interactions, individual controls, individual occupancy, individual thermal comfort, occupant preference, occupant preferences, personal comfort system, personal control, personalization, personalized control, personalized lighting settings, smart personal control, task lighting, user profiles, user profiling
visual comfort	human perception, light preference, lighting appraisal, lighting comfort, lighting preference, lighting profile, lighting retrofit, tristimulus values, view contact, view out, visual comfort, visual comfort and performance, visual discomfort, visual performance
wired communication	bacnet, dali, dali system, eib, fieldbus systems, iso/iec/ieee 21451, knx
wireless communication	internet of things, internet of things (iot), of things (iot), opc client, rfid, ultrasonic communication, visible light communication, wifi, wireless communication, wireless lighting control, wireless sensing and actuating, wireless sensor and actuator network, wireless sensor network, wireless sensor networks, wireless sensors, wsn, zigbee, zigbee light link (zll), zigbee wireless communication

The following references represent all research articles, which have been used in our analysis following the VOSviewer approach.

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