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How to protect R & D results in design — 4th industrial revolution and civil engineering innovations

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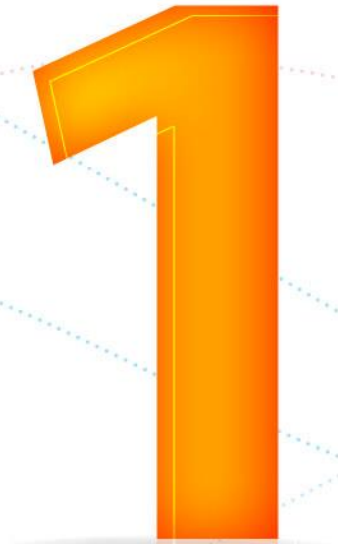
Contents



Background

4th industrial revolution (4IR)

- 54% rate of growth for 4IR patent applications in the European Patent Office (EPO) 2017 - 2019.
  - Overall growth of all patent applications 7,65 %
- The fastest-growing 4IR fields are 3D systems, artificial intelligence (AI) and user interfaces (UI).
- 4IR increases innovations also in civil engineering.
- Growing number of patents increases the risk of infringing competitors' patents.

Applications of AI in civil engineering

- Modelling (BIM) and simulation
  - Simulations of loads, strengths, stability etc.
  - Technical drawings
  - CAD
  - Cost management
  - Environmental and sustainability analysis
  - Life-cycle facility management
  - Data driven design

Applications of AI in civil engineering

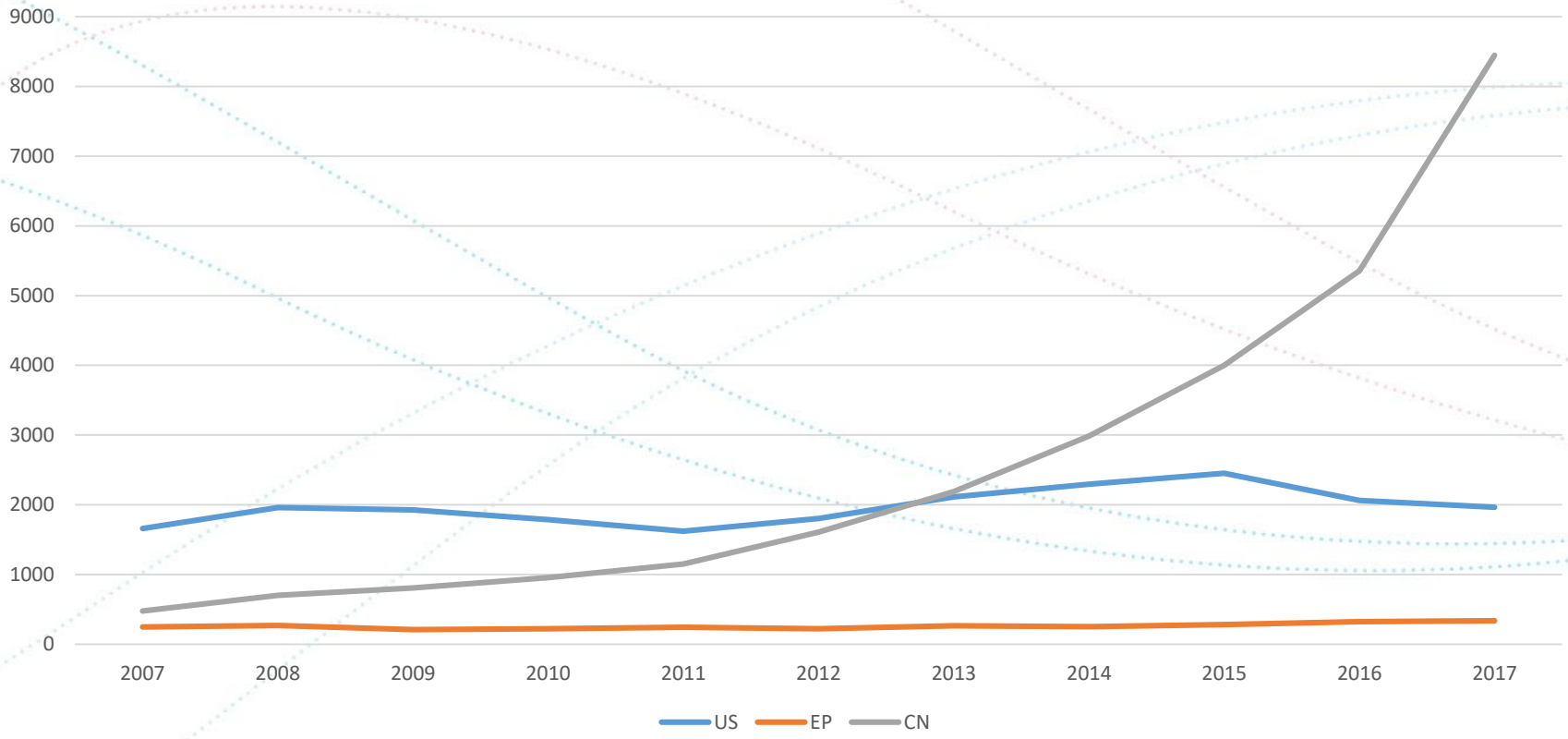
- Workflow and project management
  - Material ordering
  - Collaboration between contractors
  - Handling of documents
  - Management of contracts

Applications of AI in civil engineering

- Monitoring various conditions of buildings, bridges etc. in real-time:
  - IoT sensors
  - Predictive maintenance and control
- Intelligent robots
- 3D printing at construction sites

Patenting activity in computer-aided design

Patent applications in the largest patent offices by year of publication



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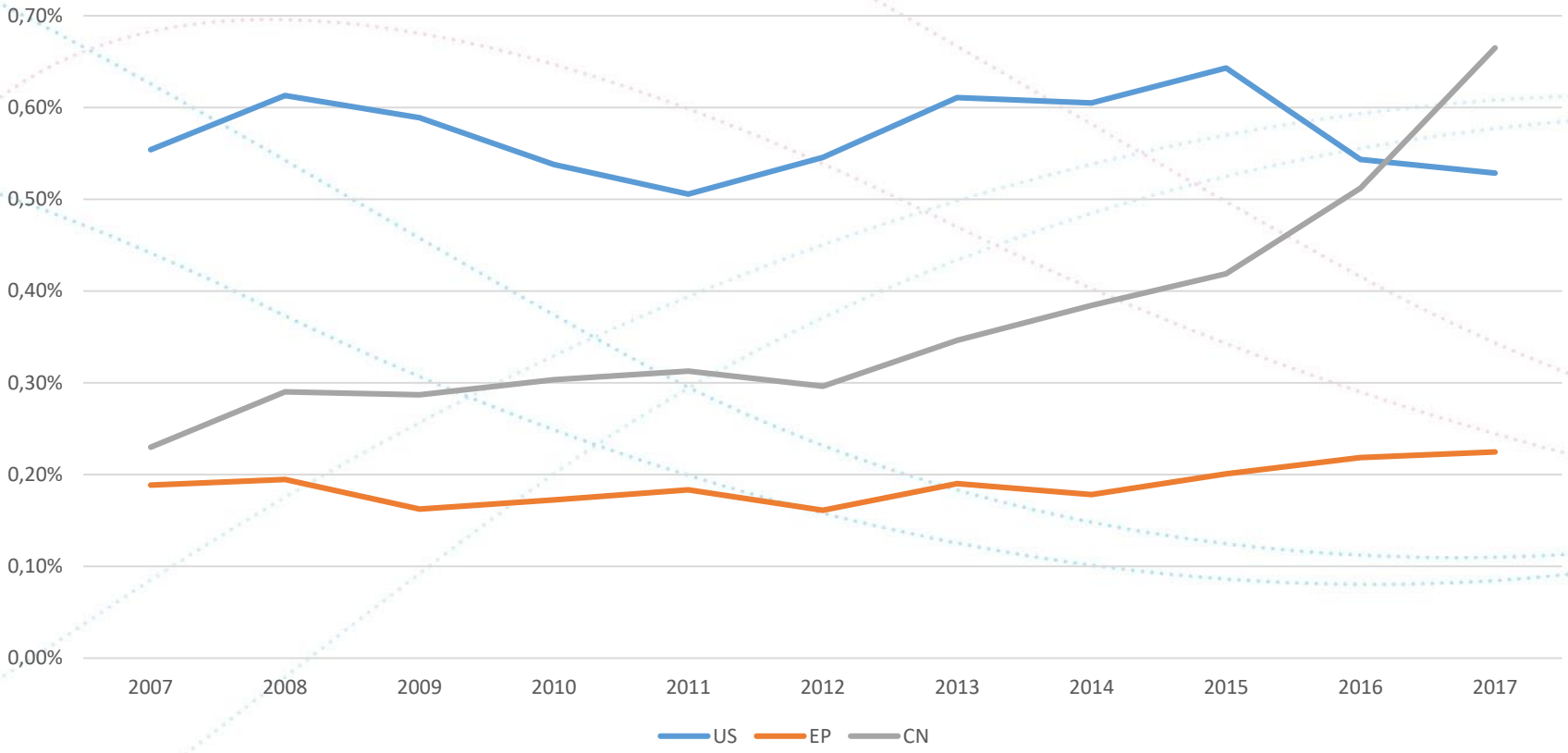
Percentage of computer-aided design applications



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Effects of 4th industrial revolution

- Inventors and enterprises should
  - protect the intangible assets of their companies in the rapidly changing economy
  - be aware of the industrial property rights of their competitors and co-operation partners

Intellectual property rights (IPR)

One product – many IP rights

Patents

- technical components (also with utility models)
- data processing methods
- details of operating system
- user interface functionalities
- applications

Trademarks

- company name
- name of product, application or service
- logo
- start-up tone or ringtone

Design rights

- overall design of product
- position and shape of display

Copyright

- software code
- user manual
- music
- images

Trade secrets

- technical solutions and know-how that can be kept secret
- cloud-based portion of data processing

Benefits of IPR

Patents, designs and trademarks are integral parts of corporate strategies of businesses:

- Protect the company against imitators
- Increase the market share
- Convince potential investors
- Avoid infringing competitors' patents and IP
- Use patent information in R&D
- Patents themselves have monetary value
- Licensing fees can be a significant source of income
- Patents, designs and trademarks are investments

Basics of patenting

Patents

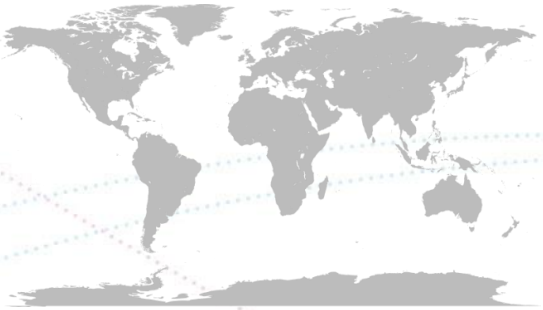
- A patent gives the owner the right to exclude others from using the invention professionally, not necessarily to use the invention
- This right to exclude others is given for a limited time (20 years) in exchange for making the invention public.
  - A patent application becomes public after 18 months since filing, unless it is withdrawn.

Basic criteria for patenting

- The sought scope of protection is defined in patent claims.
- **Novelty**
  - No prior art disclosing the claimed subject matter has become public anywhere in the world before the filing (or priority) date of the patent application.
- **Inventive step**
  - The difference between the claimed invention and the prior art is not obvious to a person having ordinary skill in the art.
- **Industrial applicability**
  - The claimed subject matter can be made or used in industry.
- **Sufficiency of disclosure**
  - The disclosure must enable a person skilled in the art to carry out the invention in the entire scope of the patent claims.
- The patent claims must be clear and concise and supported by the description.

International patenting

- Prior (or state of the) art can be any published document anywhere in the world
  - Even by the inventors!
- There is no ”global” patent or trademark
- A Finnish applicant can start with a Finnish patent application (in English) and continue abroad using the PCT system
  - Office action from PRH with search report within about 7 months
  - An international PCT application must be filed within the priority year
  - Decision to file in specific countries must be made after 30 or 31 months
  - Patent Prosecution Highway (PPH)



Requirements specific to AI inventions

What is AI?

- Artificial intelligence is created by mathematical algorithms.
- Guidelines of the European Patent Office (EPO):
  - *Artificial intelligence and machine learning are based on computational models and algorithms for classification, clustering, regression and dimensionality reduction, such as neural networks, genetic algorithms, support vector machines, k-means, kernel regression and discriminant analysis.*
  - *Such computational models and algorithms are per se of an abstract mathematical nature, irrespective of whether they can be "trained" based on training data.*

What is AI?

- *Terms such as "support vector machine", "reasoning engine" or "neural network" may, depending on the context, merely refer to abstract models or algorithms and thus do not, on their own, necessarily imply the use of a technical means.*
- AI inventions must satisfy the same patentability requirements as any invention that involves the use of mathematical methods.

Patenting of inventions involving mathematical methods

- Purely mathematical methods are excluded from patentability.
  - “Non-technical” (Europe, China)
  - "Abstract ideas” (U.S.)
- Technical solutions which use mathematical methods may be patentable.
  - “Technical effect” (Europe, China)
  - “Significantly more than an abstract idea” (U.S.)

Mathematical methods in Europe

- Patentable invention must have a technical character
- Inventive step cannot not be based on non-technical features.
- A mathematical method may contribute to the technical character of an invention
  - by its application to a field of technology

    and/or
  - by being adapted to a specific technical implementation
- Must also satisfy other patentability requirements (novelty, inventive step)

Mathematical methods in Europe

- **Technical applications**
  - Mathematical methods that serve a technical purpose in the context of the invention.
  - The technical purpose must be a specific one, e.g.
    - controlling a specific technical system or process, e.g., an X-ray apparatus or a steel cooling process
    - simulating the behaviour of an adequately defined class of technical items, or specific technical processes, under technically relevant conditions
  - A generic purpose such as "controlling a technical system" is not sufficient to confer a technical character to the mathematical method.

Mathematical methods in Europe

- **Technical applications**
  - The claim must be functionally limited to the technical purpose.
  - This can be achieved, e.g., by specifying how the input and the output of the mathematical steps relate to the technical purpose.
  - The mere fact that a mathematical method may serve a technical purpose is not sufficient.
  - Defining the nature of the data input to a mathematical method (e.g., naming parameters after physical quantities) does not necessarily imply that the mathematical method contributes to the technical character of the invention.
    - Technical purpose of the mathematical method is primarily determined by the direct technical relevance of the results it provides.

Mathematical methods in Europe

- **Technical implementations**
  - Claims that are directed to specific technical implementations of a mathematical method that address the internal functioning of a computer.
    - E.g., processing that saves memory resources of a computer
  - If a mathematical method addresses non-technical purpose, it does not contribute to the technical character of the invention.
    - In this case, it is not even sufficient that the mathematical algorithm runs faster on a computer than prior-art algorithms.
  - If a mathematical method produces a technical effect, computational efficiency is taken into account in the assessment of patentability.

Computer-implemented simulation and modelling methods in Europe

- Computer-implemented simulation of the behaviour of an adequately defined class of technical items, or specific technical processes, under technically relevant conditions qualifies as a technical purpose, e.g.
  - numerical simulation of the performance of an electronic circuit subject to 1/f noise
  - numerical simulation of a specific industrial chemical process.
- Computer-implemented simulation methods cannot be denied a technical effect merely on the ground that they precede actual production and/or do not comprise a step of manufacturing the physical end product.

Computer-implemented simulation and modelling methods in Europe

- In CAD design of a specific technical object, the determination of a technical parameter intrinsically linked to the functioning of the technical object is a technical purpose if the determination is based on technical considerations.
  - In CAD design of an optical system, the use of a particular formula for determining technical parameters (refractive indices and magnification factors) for given input conditions so as to obtain optimal optical performance makes a technical contribution.
  - Determining by iterative computer simulations the maximum value that an operating parameter of a nuclear reactor may take without risking rupture of a sleeve due to stress makes a technical contribution.

Computer-implemented simulation and modelling methods in Europe

- The simulation of non-technical processes does not represent a technical purpose, e.g.
  - marketing campaign
  - administrative scheme for transportation of goods
  - determining a schedule for agents in a call centre
- A generic limitation, such as "simulation of a technical system", does not define a relevant technical purpose.
- A technical effect of improved design must be causally linked to the claim features.
  - Effect cannot be acknowledged if decisions are taken by a human user and the technical considerations for taking such decisions are not specified in the claim.

Computer-implemented simulation and modelling methods in Europe

- If a computer-implemented method results merely in an abstract model of a product, system or process, e.g. a set of equations, this per se is not considered to be a technical effect, even if the modelled product, system or process is technical.
  - A logical data model for a family of product configurations has no inherent technical character.
  - A method merely specifying how to describe a multi-processor system in a graphical modelling environment does not make a technical contribution.

Technical character of AI applications in civil engineering

- Modelling (BIM) and simulation: Grey area as a whole
  - Simulations of loads, strengths, stability etc.: Mostly technical
  - Technical drawings: Mostly non-technical
  - CAD: Aspects of computer graphics may be technical.
  - Cost management: Non-technical
  - Environmental and sustainability analysis: Depends on whether technical parameters are analysed or not.
  - Life-cycle facility management: Administrative aspects and collaboration between different actors are non-technical activities.
  - Data driven design: Depends on data and design results

Technical character of AI applications in civil engineering

- Workflow and project management: Mostly non-technical
  - Material ordering: Mostly non-technical
  - Collaboration between contractors: Mostly non-technical
  - Handling of documents: Non-technical
  - Management of contracts: Non-technical

Technical character of AI applications in civil engineering

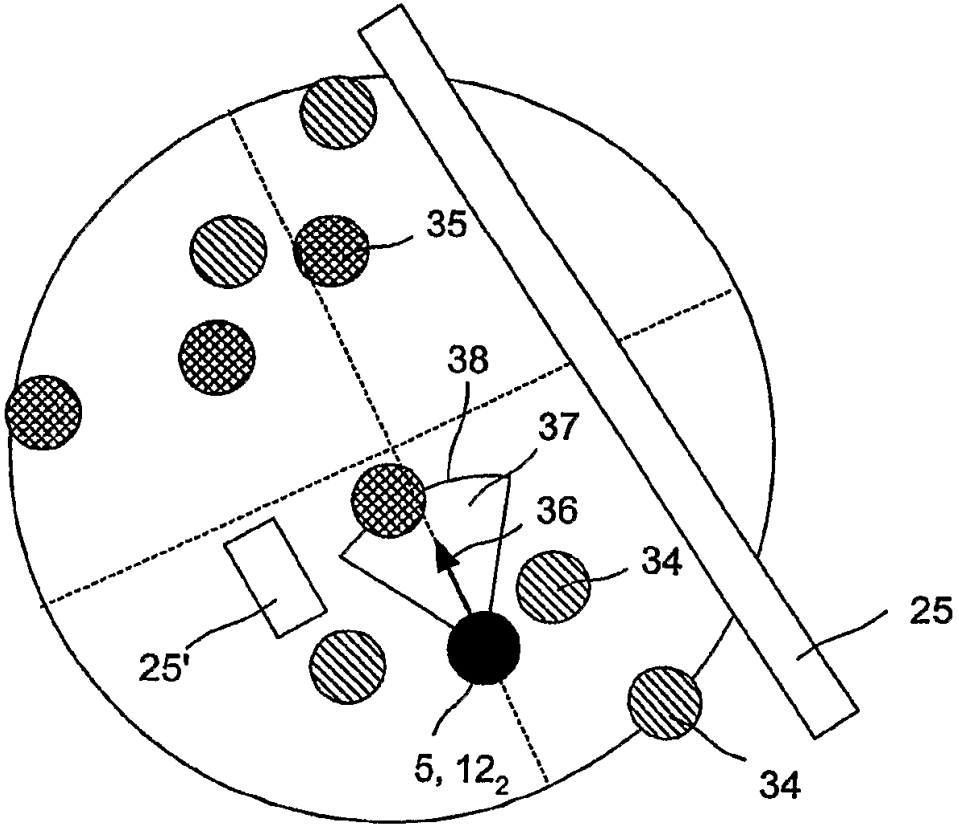
- Monitoring various conditions of buildings, bridges etc. in real-time: Mostly technical
  - IoT sensors: Mostly technical
  - Predictive maintenance and control: Mostly technical
- Intelligent robots: Mostly technical
- 3D printing at construction sites: Mostly technical

Computer-implemented simulation and modelling methods in Europe

- Referral to an enlarged board of appeal has been made at the EPO regarding an invention directed to a computer-implemented method of modelling pedestrian crowd movement in an environment.
  - A mathematical model is presented for simulating the movement of a plurality of pedestrians step by step, taking into account factors related to deviations from a given direction and speed, as well as obstructions (including other pedestrians).

Computer-implemented simulation and modelling methods in Europe

Pedestrian simulation



Computer-implemented simulation and modelling methods in Europe

- An alternative claim set is directed to a method of designing a building structure where method comprises
  - providing a model of said building structure
  - simulating movement of a plurality of pedestrians through said building structure using a computer, wherein simulating movement of each pedestrian step comprises
  - ... (the mathematical model) ...
  - revising said model of said building structure in dependence upon movement of the pedestrians.

Computer-implemented simulation and modelling methods in Europe

- The original (non-enlarged) board had a negative opinion on all the claim sets.
  - *Numerically calculating the trajectory of an object as determined by the laws of physics is not in itself a technical task producing a technical effect.*
  - A link with physical reality is missing.
  - The environment being modelled may not exist and may never exist.
  - The simulation could be run to support purely theoretical scientific investigations, or it could be used to simulate the movement of pedestrians through the virtual world of a video game.

Computer-implemented simulation and modelling methods in Europe

- *In the alternative claim set where the method is directed to designing a building structure, the description of the application makes it clear that the step of revising the model of the building structure may be performed by a human designer operating a CAD program.*
- *The simulation does not causally lead to an improved environment design because any changes made to the design in response to simulation results are still the result of the intellectual activity of the designer.*

Computer-implemented simulation and modelling methods in Europe

- Referral to the enlarged board of appeal has been made in order to clarify what are the relevant criteria for assessing whether a computer-implemented simulation claimed as such solves a technical problem.
- A decision could be expected as early as this year.

Sufficiency of disclosure

- Applicants often want to patent the basic outline of the AI algorithm
  - A "black box" algorithm: input data → “AI” → solution
  - Meta-level idea, typically not allowable.

Sufficiency of disclosure

- Terms such as “machine learning algorithm”, “artificial neural network”, “reinforcement learning” etc. merely refer to general frameworks that encompass a vast multitude of potential mathematical models.
- Neural networks
  - There are countless ways to combine individual neurons into a neural network.
  - Neural networks may contain thousands of parameters.
  - Without specification of the topology of the neural network, the number of nodes and their connections, weights, propagation functions, initial values, cost functions or learning algorithms, organisation of input data and output data into a form required by the specific type of a neural network, a person skilled in the art is faced with an undue burden of trial and experimentation.

Sufficiency of disclosure

- An AI algorithm must be disclosed so that a person skilled in the art is able to implement it without undue burden
  - At least one detailed way of carrying out the claimed invention must be disclosed .
  - The whole claimed scope must be enabled.
  - The level of skill is similar in determining enablement and inventive step.

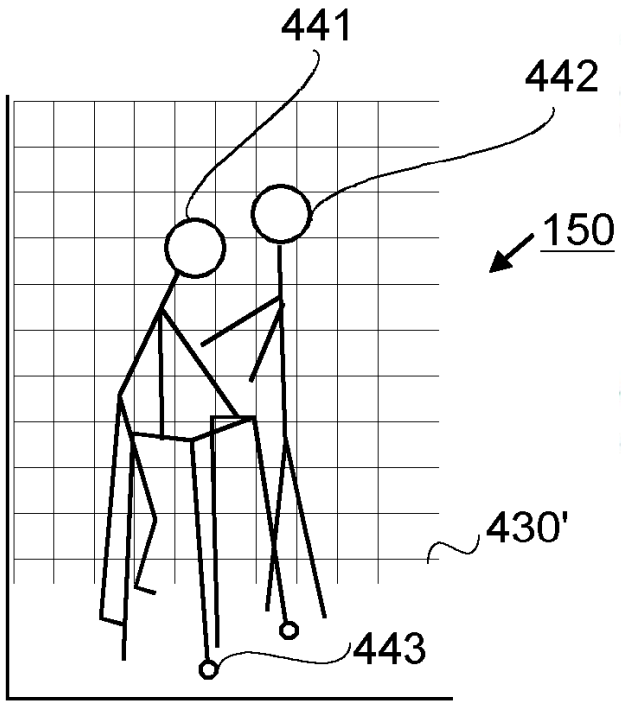
Patenting AI inventions in the U.S.

- Many principles are similar, but the concepts of technicality, technical effect or technical problem are not used in the U.S.
  - Different principles are used for assessing non-obviousness (= inventive step in Europe)
- To be patent eligible, the invention must involve significantly more than an abstract idea
  - Not just an abstract idea implemented on a common computer and communication network
  - However, a practical application of a judicial exception (such as an abstract idea) is patent eligible
- Eligibility is assessed separately from novelty and non-obviousness
  - Novelty and non-obviousness over a prior art solution can be based on an abstract idea (i.e., abstract features)
  - This contrasts with EPO practice, where inventive step cannot be based on non-technical features.

Examples of granted patents

I FI125913B

- A CAD application for designing rooms or buildings for specific purposes, like homes for elderly people.
- An action space object is provided that defines a volume needed to carry out a specific activity/action.



I FI125913B

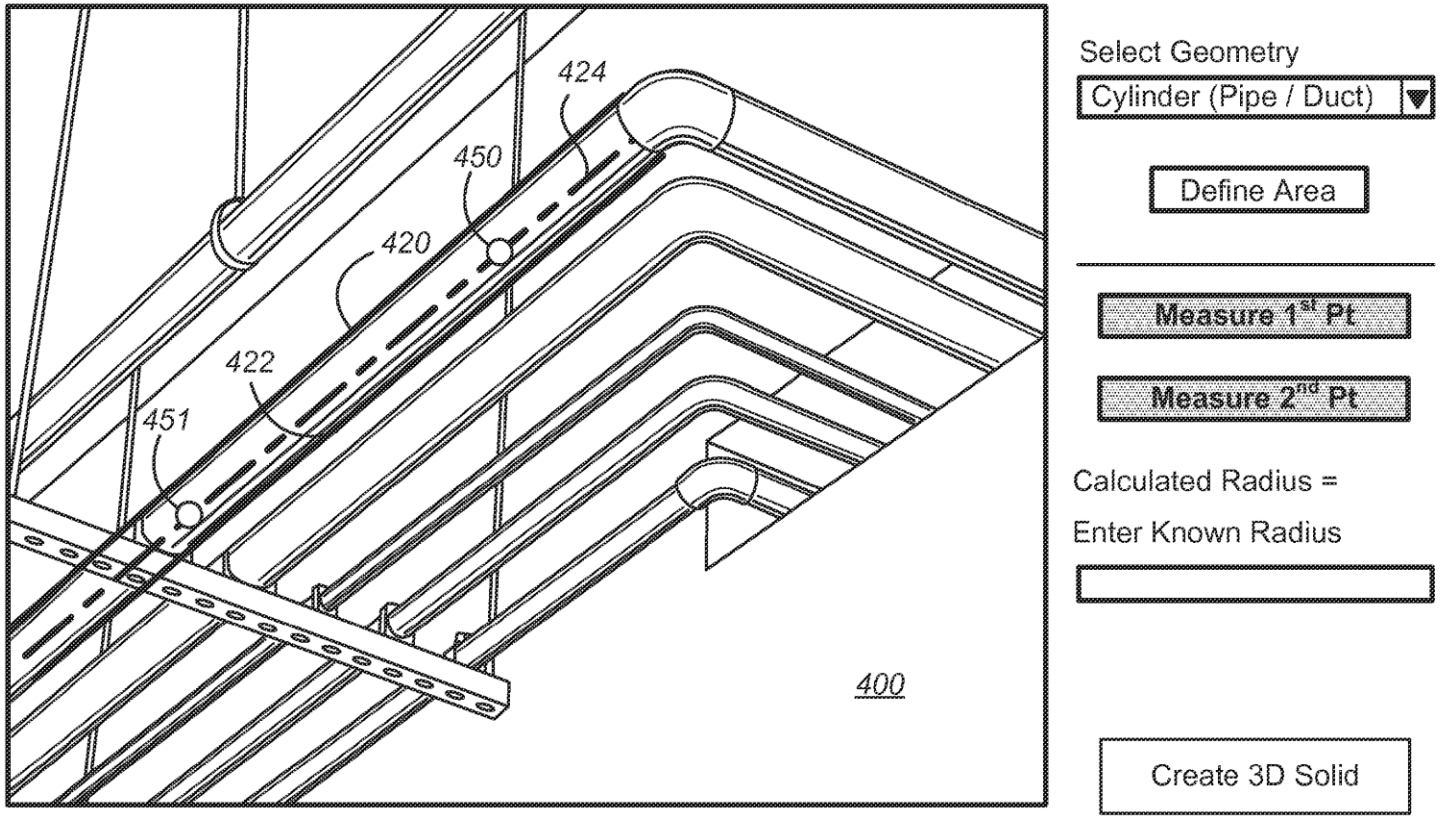
- The claims are directed to a computer implemented method that comprises (in an abridged form)
  - obtaining video or laser scanner data that represents a specific activity performed by at least one person from different directions
  - determining from the data extreme values for coordinates in a three dimensional coordination system
  - defining dimensions for a 3D shape from the extreme values
  - creating a 3D action space object having the defined dimensions, the 3D action space object illustrating a space needed for performing the specific activity by at least one person
  - storing the 3D action space object.

I FI125913B

- Patent granted in Finland. What about family members elsewhere?
- US10296667
  - Patent granted in a more detailed form than in Finland.
- EP2979208
  - Considered non-technical in the first office action.
  - Application is still pending.
- CA2907520
  - Application pending
  - Examination requested

II EP3055648

3D modeling using feature detection

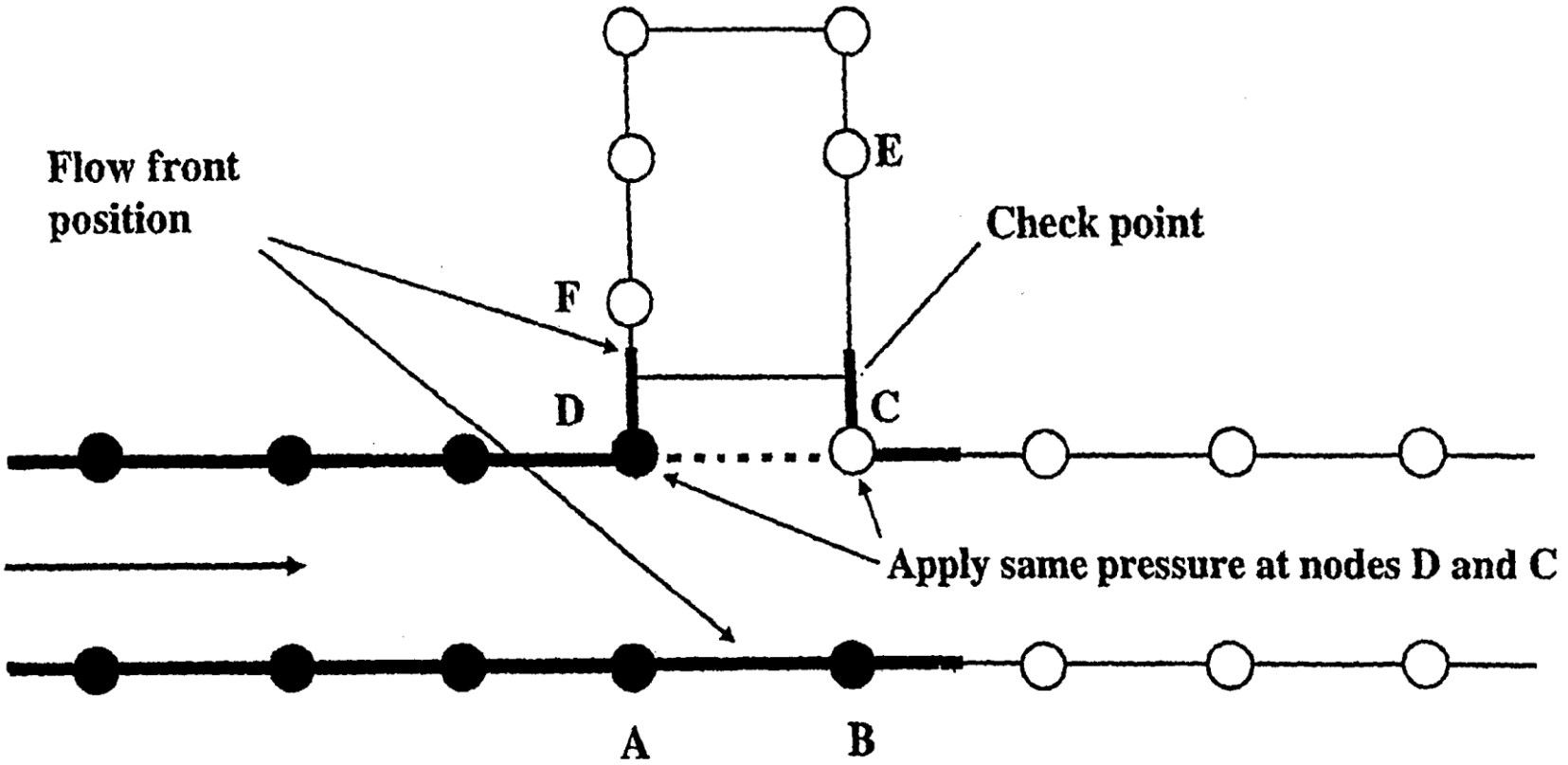


II EP3055648

- The method involves presenting an image of a scene to a user.
- A geometry type associated with one of the objects in the image is received.
- A set of inputs is received from the user related to the object.
- A centerline of the object is determined.
- The inputs from the user and the coordinate positions along the centerline are measured.
- A dimension associated with the object is received.
- A 3D solid model is created using the geometry type, the dimension, the set of inputs, and the coordinate positions.

III EP0968473

Fluid flow simulation

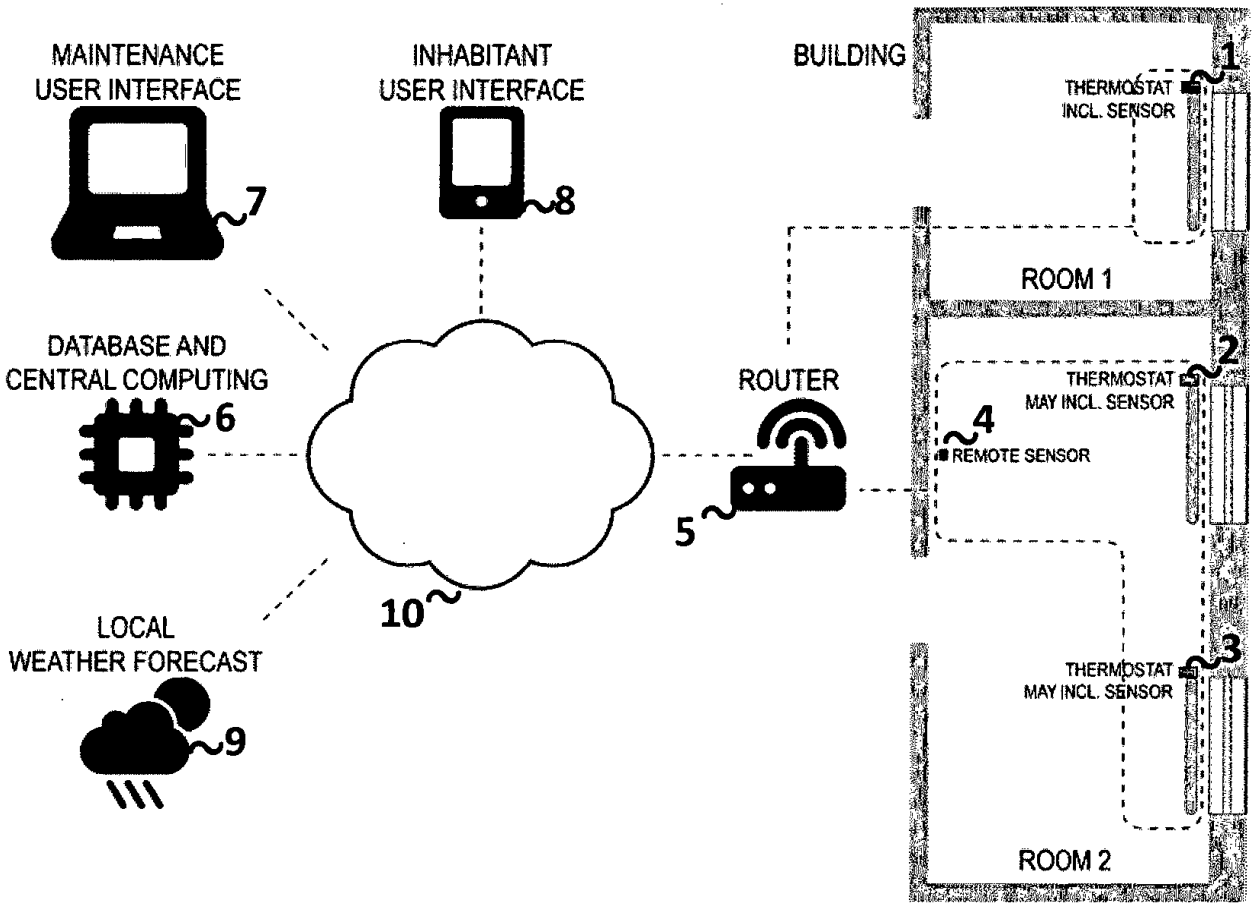


III EP0968473

- A method for simulating fluid flow within an object that has first and second surfaces.
- Each element (DF) of the first surface is matched with an element (CE) of the second surface, between which a reasonable thickness may be defined.
- A fluid injection point is specified and a flow analysis is performed using each set of matched elements:
  - The injection point is linked to all points on the first and second surfaces from which flow may emanate.
  - The resulting flow fronts along the first and second surfaces are synchronised.

IV EP2866117

Distributed adaptive and predictive heating control



IV EP2866117

- The distributed adaptive and predictive heating control system comprises thermostats (1,2,3) that are arranged to
  - control the local temperature of associated rooms
  - transmit measured temperature data to a central computing entity (6).
- The central computing entity has a user interface (7,8), and it is arranged to
  - receive and collect data from thermostats and optional sensors
  - receive and collect operational settings through the user interface

IV EP2866117

- The central computing entity is futher arranged to
  - calculate control responses of rooms
  - based on the control responses, calculate and transmit updated control parameters to the thermostats
  - calculate time domain performances of rooms, taking also into account measured outside temperatures
  - calculate heat control timings for rooms based on their time domain performances and predicted temperatures outside the rooms, where
  - the predicted temperature outside each room is
    - a temperature prediction of another room based on the heat response of that room or
    - a temperature prediction outside the building based on local weather forecast data

V EP3132921

Creating a fastening arrangement using additive manufacturing techniques

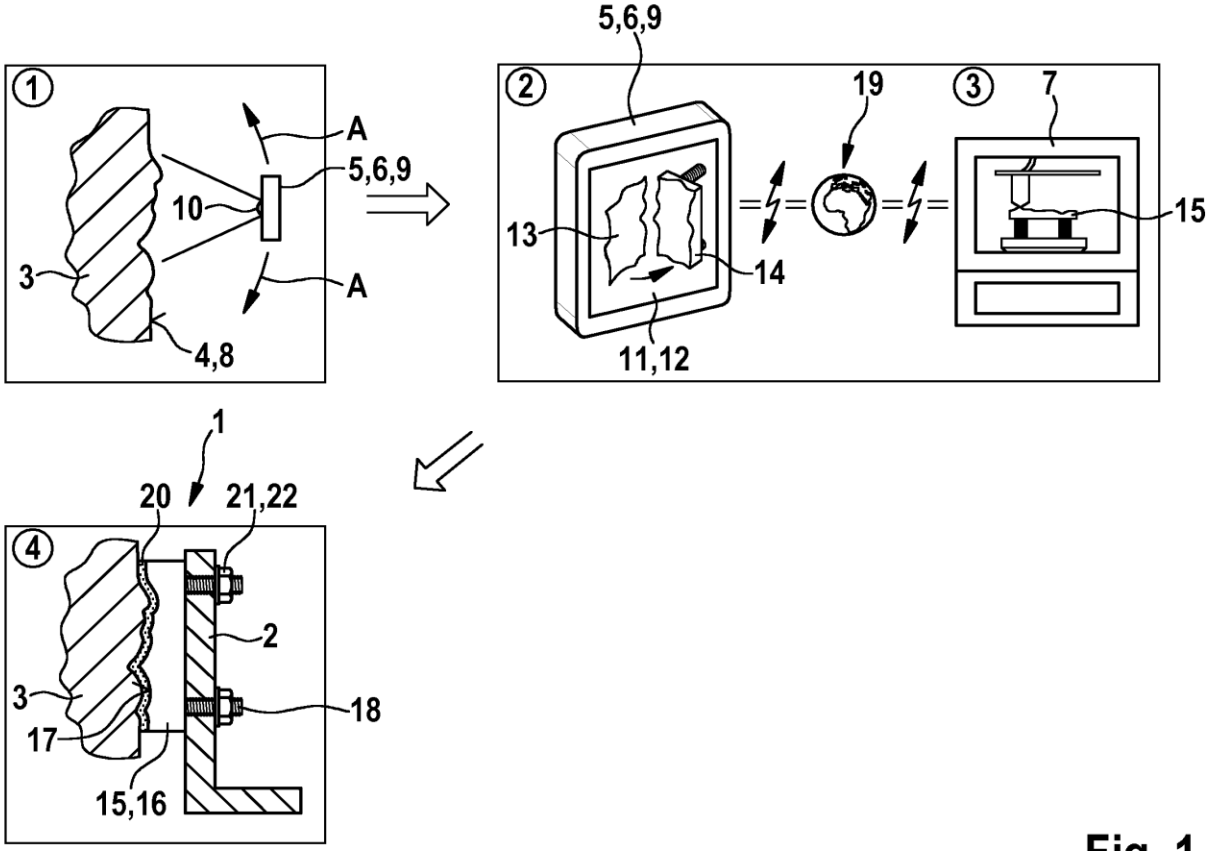


Fig. 1

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V EP3132921

- The system has a sensor system (5) that is comprised to perform sensory detection of situation data (13) of a fastening situation.
- A computer-based expert system (6) is comprised to generate digital element data (14) of an attachment element (15) in dependence on the situation data.
- A three-dimensional (3D) printer (7) is comprised to produce the attachment element in dependence on the element data.

Conclusions

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Factors weighing for patentability

- Specific technical target of AI algorithms in the claims
- Well-defined, concrete technical problem to be solved
- Specific solution to the technical problem in the claims
- Results directly applicable to further technical use

Factors weighing against patentability

- Broad, non-technical or ambiguous target of AI algorithms in the claims
- Problem to be solved unclear, non-technical or overly general
- Solution presented in the claims not necessarily limited to a technical problem
- Non-technical or unspecified use for results

Remember

- AI applications in civil engineering can be patented if they are limited to a technical purpose.
  - Non-technical applications might be patentable outside Europe.
- Modelling and simulation inventions fall within the grey area of patenting.
  - Important to identify a specific technical purpose, technical problem and technical solution with a technical effect.
- Do not forget to disclose at least one detailed embodiment of AI algorithms in the application!
- Skilled and experienced patent attorney needed

PRH services (www.prh.fi)

- Examination of national and international (PCT) applications
  - Different patenting criteria (U.S. in particular) taken into account in the examination.
- Commercial search services
  - Report on the state of the art
  - Competitor monitoring
  - Novelty search and patentability report
  - Freedom-to-operate
  - Validity search
  - Customizable reports possible

Thank you!

Questions?

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