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(54) Title: METHOD AND SYSTEM FOR PRODUCTION ANALYSIS USING DATA ANALYTICS

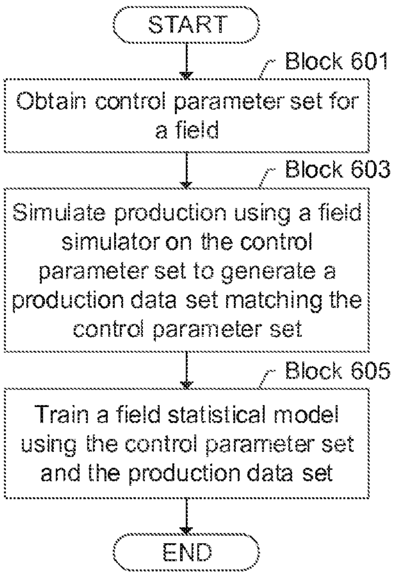

FIG. 6

(57) Abstract: Production analysis includes obtaining a first control parameter set for a field, simulating production using a field simulator on the first control parameter set to generate a first production data set matching the first control parameter set, and training a field statistical model using the first control parameter set and the first production data set. Production analytics further includes obtaining a second control parameter set, executing the field statistical model on the second control parameter set to obtain a second production data set defining a production in the field, and presenting the second production data set.

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METHOD AND SYSTEM FOR PRODUCTION ANALYSIS USING DATA ANALYTICS

BACKGROUND

[0001] Operations, such as geophysical surveying, drilling, logging, well completion, and production, are performed to locate and gather hydrocarbons from subterranean formations. A technique for extracting hydrocarbons is to induce fractures in the reservoir, thereby causing such fluids to be pulled to the surface. Such induced fractures may propagate through the subsurface formations.

SUMMARY

[0002] One or more embodiments of the technology are directed to production analysis using data analytics. Production analysis includes obtaining a first control parameter set for a field, simulating production using a field simulator on the first control parameter set to generate a first production data set matching the first control parameter set, and training a field statistical model using the first control parameter set and the first production data set. Production analytics further includes obtaining a second control parameter set, executing the field statistical model on the second control parameter set to obtain a second production data set defining a production in the field, and presenting the second production data set.

[0003] Other aspects of the technology will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0004] FIGs. 1-4 show example schematic diagrams of systems in accordance with one or more embodiments.

[0005] FIGs. 5-7 show flowcharts in accordance with one or more embodiments.

DETAILED DESCRIPTION

[0006] Specific embodiments of the technology will now be described in detail with reference to the accompanying figures. Like elements in the various figures are denoted by like reference numerals for consistency.

[0007] In the following detailed description of embodiments of the disclosure, numerous specific details are set forth in order to provide a more thorough understanding of the disclosure. However, it will be apparent to one of ordinary skill in the art that the embodiments may be practiced without these specific details. In other instances, well-known features have not been described in detail to avoid unnecessarily complicating the description.

[0008] Throughout the application, ordinal numbers (e.g., first, second, third, etc.) may be used as an adjective for an element (i.e., any noun in the application). The use of ordinal numbers is not to imply or create any particular ordering of the elements nor to limit any element to being a single element unless expressly disclosed, such as by the use of the terms "before", "after", "single", and other such terminology. Rather, the use of ordinal numbers is to distinguish between the elements. By way of an example, a first element is distinct from a second element, and the first element may encompass more than one element and succeed (or precede) the second element in an ordering of elements.

[0009] In general, embodiments are directed to production analysis using data analytics. Specifically, one or more embodiments generate synthetic production data sets using a field simulator by simulating input control parameter sets. Using the synthetic production data sets and the corresponding input control parameter sets, a field statistical model may be generated. The field statistical model may then be used to model production of the field.

[0010] FIG. 1 depicts a schematic view, partially in cross section, of a field (100) in which one or more embodiments may be implemented. In one or more embodiments, the field may be an oilfield. In other embodiments, the field may be a different type of field. In one or more embodiments, one or more of the modules and elements shown in FIG. 1 may be omitted, repeated, and/or substituted. Accordingly, embodiments should not be considered limited to the specific arrangements of modules shown in FIG. 1.

[0011] As shown in FIG. 1, the subterranean formation (104) may include several geological structures (106-1 through 106-4) of which FIG. 1 provides an example. As shown, the formation may include a sandstone layer (106-1), a limestone layer (106-2), a shale layer (106-3), and a sand layer (106-4). A fault line (107) may extend through the formation. In one or more embodiments, various survey tools and/or data acquisition tools are adapted to measure the formation and detect the characteristics of the geological structures of the formation. Further, as shown in FIG. 1, the wellsite system (110) is associated with a rig (101), a wellbore (103), and other wellsite equipment and is configured to perform wellbore operations, such as logging, drilling, fracturing, production, or other applicable operations. The wellbore (103) may also be referred to as a borehole. Generally, survey operations, drilling, production operations, and engineering completion operations are referred to as field operations of the field (100). These field operations may be performed as directed by the surface unit (112).

[0012] In one or more embodiments, the wellsite system may include functionality to perform hydraulic fracturing operations. Hydraulic fracturing, or fracturing, is a process that uses fluid pressure to enhance well production, such as an oil and gas well, above natural production rates. Fluid pressure is applied to rock to overcome the earth stresses and strength of the rocks, causing the rock to part. Solid materials are then mixed with the fluid and pumped into the induced fracture to prevent closing of the fracture after the fluid pressure is removed. This process creates a large surface area through which hydrocarbons can flow and a pathway for those hydrocarbons to reach the well. The result is that the rate of flow is greatly increased compared to an un-stimulated well in the same reservoir.

[0013] The production from the wellsite system may be dependent on several factors. For example, the production may be dependent on the properties of the rock, size of reservoir, physical dimensions of factors, and control parameters. The physical dimensions of the fracture or fractures, and the fracture's confinement to the intended rock strata from which hydrocarbons will be produced, are governed by geological structures of the subterranean formation. For example, the properties of the rock, Earth stresses in the reservoir and bounding layers, the pressure that is applied to the rock formations during a hydraulic fracturing treatment, and the volumes of materials used may affect the fractures. The physical dimensions may also vary with time.

[0014] The wellsite system (110) may include specialized equipment that mixes the fluid used for fracturing, adds proppant to the fluid, elevates the pressure of the fluid to a level that causes the fracture to open, and delivers the high pressure fluid to the well. The distance that the fracture propagates from the well is dependent upon the total volume of fluid and proppant that is pumped and the rate that they are injected. The length and height, or geometry, of the induced fracture dictates flow rate and ultimate recovery of hydrocarbons from the well.

[0015] In one or more embodiments, the surface unit (112) is operatively coupled to a field management tool (116) and/or the wellsite system (110). In particular, the surface unit (112) is configured to communicate with the field management tool (116) and/or the wellsite system (110) to send commands to the field management tool (116) and/or the wellsite system (110) and to receive data therefrom. For example, the wellsite system (110) may be adapted for measuring downhole properties using logging-while-drilling ("LWD") tools to obtain well logs and for obtaining core samples. In one or more embodiments, the surface unit

(112) may be located at the wellsite system (110) and/or remote locations. The surface unit (112) may be provided with computer facilities for receiving, storing, processing, and/or analyzing data from the field management tool (116), the wellsite system (110), or other part of the field (100). The surface unit (112) may also be provided with or functionally for actuating mechanisms at the field (100). The surface unit (112) may then send command signals to the field (100) in response to data received, for example, to control and/or optimize various field operations described above.

[0016] In one or more embodiments, the data received by the surface unit (112) represents characteristics of the subterranean formation (104) and may include microseismic data and/or information related to porosity, saturation, permeability, natural fractures, stress magnitude and orientations, elastic properties, *etc*. during a drilling, fracturing, logging, or production operation of the wellbore (103) at the wellsite system (110).

[0017] In one or more embodiments, the surface unit (112) is communicatively coupled to the field management tool (116). Generally, the field management tool (116) is configured to analyze, model, control, optimize, or perform other management tasks of the aforementioned field operations based on the data provided from the surface unit (112). Although the surface unit (112) is shown as separate from the field management tool (116) in FIG. 1, in other examples, the surface unit (112) and the field management tool (116) may also be combined.

[0018] FIG. 2 shows an example schematic diagram of a hardware environment of the field management tool in accordance with one or more embodiments. As shown in FIG. 2, the field management tool may be or may execute on a computing system. For example, as shown in FIG. 2, the computing system (200) may include one or more computer processor(s) (202), associated memory (204) (*e.g.,* random access memory (RAM), cache memory, flash memory, *etc.*), one or more storage device(s) (206) (*e.g.,* a hard disk, an optical drive such as a compact disk (CD) drive or digital versatile disk (DVD) drive, a flash memory stick, *etc.*), and numerous other elements and functionalities. The computer processor(s) (202) may be an integrated circuit for processing instructions. For example, the computer processor(s) may be one or more cores, or micro-cores of a processor. The computing system (200) may also include one or more input device(s) (210), such as a touchscreen, keyboard, mouse, microphone, touchpad, electronic pen, or any other type of input device. Further, the computing system (200) may include one or more output device(s) (208), such as a screen (*e.g.,* a liquid crystal display (LCD), a plasma display, touchscreen, cathode ray tube (CRT) monitor, projector, or other display device), a printer, external storage, or any other output device. One or more of the output device(s) may be the same or different from the input device(s). The computing system (200) may be connected to a network (212) (*e.g.,* a local area network (LAN), a wide area network (WAN) such as the Internet, mobile network, or any other type of network) via a network interface connection (not shown). The input and output device(s) may be locally or remotely (*e.g.*, via the network (212)) connected to the computer processor(s) (202), memory (204), and storage device(s) (206). Many different types of computing systems exist, and the aforementioned input and output device(s) may take other forms.

[0019] Software instructions in the form of computer readable program code to perform embodiments of the technology may be stored, in whole or in part, temporarily or permanently, on a non-transitory computer readable medium such as a CD, DVD, storage device, a diskette, a tape, flash memory, physical memory, or any other computer readable storage medium. Specifically, the software instructions may correspond to computer readable program code that when executed by a processor(s), is configured to perform embodiments of the technology.

[0020] Further, one or more elements of the aforementioned computing system (200) may be located at a remote location and connected to the other elements over a network (212). Further, embodiments of the technology may be implemented on a distributed system having a plurality of nodes, where each portion of the technology may be located on a different node within the distributed system. In one embodiment of the technology, the node corresponds to a distinct computing device. The node may correspond to a computer processor with associated physical memory. The node may correspond to a computer processor or micro-core of a computer processor with shared memory and/or resources.

[0021] FIG. 3 shows an example schematic diagram of a field management tool in accordance with one or more embodiments. As shown in FIG. 3, the field management tool (302) may include a data repository (304), sampler (306), field simulator (308), statistical model generator (310), and interface (312). Each of these components is described below.

[0022] In one or more embodiments of the technology, the data repository (304) is any type of storage unit and/or device (*e.g.,* a file system, database, collection of tables, or any other storage mechanism) for storing data. Further, the data repository (304) may include multiple different storage units and/or devices. The multiple different storage units and/or devices may or may not be of the same type or located at the same physical site. The data repository (304) includes functionality to store field simulator data (314), control parameter (318), valid ranges (320), and field training data.

[0023] Field simulator data (314) is data used by a field simulator to simulate the field and production operations from the field. For example, field simulator data may include subsurface properties, reservoir properties, actual input control parameters and actual output control parameters for the same wellsite and/or for other wellsites. As used herein, actual refers to information that is used in real or physical field operations and the resultant real production. For example, the field simulator data (314) may include a three dimensional model of the subsurface formation, fluid properties, and other data that may be used by a simulator.

[0024] Continuing with the data repository (304), the data repository (304) may include control parameters (318) and valid ranges (320). A control parameter is a parameter that may be modified during actual field operations to change the resulting production. For example, if a wellsite has not been drilled, the control parameters may be the position of the wellsite, trajectory of the wellbore, dimensions of the wellbore, and other information.

[0025] The control parameters may include, for example, reservoir production parameters, well completion parameters, fracture simulation parameters, stimulation parameters, production parameters, other parameters, or a combination thereof. Reservoir production parameters may include, for example, pressure volume temperature data and settings, fluid and gas saturations, indicators of reservoir quality and completion quality, and relative permeabilities. Well/Completion parameters may include, for example, lateral length, landing and trajectory, number of stages and clusters, treatment operations per stage, spacing between clusters, engineered or geometric completion, and well spacing. Fracture simulation may include, for example, variables of the discrete fracture network, and variables of the hydraulic fracturing technique. Stimulation parameters may include, for example, volume, composition, and type of fluid and proppant, type of water used, fluid formulation, treatment rate, proppant ramping and pulsing, and diversion technique. Production parameters may include, for example, wellhead pressure, applied drawdown, produced flowback, decline rate, and artificial lift method. The control parameters may optionally include reservoir geological, mechanical and petrophysical parameters, such as net pay, porosity, lithology, total organic carbon (TOC) content, petroleum maturity, natural fracture network, reservoir structure.

[0026] In one or more embodiments, each control parameter is related in the data repository to a valid range (320). In other words, the data repository includes a mapping between a control parameter and the valid range for the control parameter. The valid range (320) is a range of values that is possible for the control parameter. The valid range (320) may be continuous range, a discrete range, a set of values, or any other function defining a range. In one or more embodiments, the valid range may be defined on a per operator basis. In other words, each operator may have a valid range of values, which may be different than other operators. In such a scenario, the valid range is the values for the control parameter that has been historically used by the operator. The valid range may be expanded by a predefined statistical margin to account for additional variation by the operator. Similarly, values in the valid range may be associated with a probability function defining the probability of each value in the valid range.

[0027] Field training data (316) includes training data for training the statistical model. Field training data (316) may include control parameter sets and corresponding production data sets. The control parameter sets includes a value for each control parameter. In other words, a control parameter set is set of values that may be used in a run of actual field operations. In one or more embodiments, a single control parameter set may define a single option in drilling and/or producing from the wellsite. For example, the single control parameter set may have a single value for each corresponding control parameter.

[0028] Production data set is a data set defining resultant production from control parameter data set. For example, production data set may include the amount produced, composition of hydrocarbons produced, flowrates, any other data describing production, or any combination thereof. In one or more embodiments, the production data set may be a production profile. A production profile describes production over a span of time. For example, the production profile may include an amount produced for three months, one year, three years, and five years. Other time spans may exist without departing from the scope of the claims. In some embodiments, the production data set includes a snapshot production for a single point in time and/or a cumulative production amount. Other variations of the production profile may exist without departing from the scope of the disclosure.

[0029] Continuing with the field management tool (302), the sampler (306) includes functionality to sample multidimensional space. In some embodiments, the sampler includes functionality to obtain a value from the valid ranges (320) for each control parameter (318). For example, the sampler (306) may be configured to obtain data based on a relative probability of each value in the data set.

[0030] In one or more embodiments, the field simulator (308) includes functionality to simulate a field operation of the field. For example, the field simulator (308) may be configured with math, physics, geology, fluid dynamics, and other engineering information to simulate the effects of the control parameter set on the field operation. In other words, the field simulator (308) may simulate the interaction between the equipment and other inputs to the reservoir being configured according to the control parameter set. The field simulator (308) may be configured to generate, as output, production data. For example, the field simulator may be a reservoir simulator, a drilling simulator, a production network simulator, other simulator, or a combination of simulators.

[0031] In one or more embodiments, the statistical model generator (310) is a statistical analyzer that is configured to generate, based on multivariate statistics, a statistical model using the field training data (316). A statistical model is a model that takes, as input, a control parameter set and, generates, as output, a production data set based on statistics. In other words, the statistical model generates the production data set based on probabilities of the production data sets when provided with the control parameter set. For example, the output of the statistical model may be an expected production data set, and other statistical analysis results, such as mean and variance. In one or more embodiments, the statistical model may exclude fluid dynamics, physics based, and other such calculations.

[0032] The interface (312) may correspond to any application programming interface, a hardware interface, and/or user interface for interacting with the field management tool. For example, the interface may include an application programming interface to communicate with a program. The hardware interface may include device drivers and controllers for sending command signals to equipment located at the wellsite in order to perform field operations. The user interface may include functionality to receive valid ranges and other information from the user and transmit production data sets and other information to the user. For example, the user interface may include various user interface widgets for interacting with the user.

[0033] FIG. 4 shows an example diagram of field training data (402) in accordance with one or more embodiments. In particular, FIG. 4 shows relationships between control parameter sets and production data sets in accordance with one or more embodiments. In other words, FIG. 4 shows types of relationships that may exist between actual and synthetic data.

[0034] For example, the field training data set (402) may include an actual control parameter set (404) that is related to actual production data set (406). In other words, when a field operation is performed on a well, the inputs and results of the field operation are known and stored in the field training data. The performance of the field operation may be on the same wellsite, a similar wellsite at the same field, a similar wellsite at a different field, based on history matching, or other field operation. Similar may be defined as being within a threshold difference with regards to property values of the corresponding entity (e.g., wellsite, field).

[0035] By way of another example, actual control parameter set (408) may be related in the field training data set (402) to synthetic production data set (410). In such a scenario, when a field operation is performed in actuality at a wellsite, the inputs to the field operation are obtained and stored in the field training data (402) while the outputs are unknown. In such a scenario, the actual control parameter set (408) may be provided, as input, to the field simulator in order to obtain the synthetic production data set (410). In such a scenario, the synthetic production data set (410) is an estimation of the outcome resulting from using the actual control parameter set (408).

[0036] In another example, a synthetic control parameter set (412) may be related to a synthetic production data set (414). In particular, the synthetic control parameter set is a generated manifestation of control parameter values to use as input, which is not stored based on usage in the field. For example, the synthetic control parameter set (412) may be a perturbing of an actual control parameter set (e.g., actual control parameter set (408), actual control parameter set (404)). By way of another example, the synthetic control parameter set (412) may be a sampling of multivariate space generated based on the valid ranges of one of more control variables. The corresponding synthetic production data set (414) is a production data set that is generated using the field simulator.

[0037] Although FIG. 4 is described with respect to control parameter sets as being synthetic or actual, a single control parameter set may include some control parameters that are synthetic and some control parameters that are actual. Similarly, the control parameters that are synthetic may include control parameter values generated based on sampling and control parameter values generated based on perturbing the actual control parameters values. Likewise, a production data set may include actual production data and synthetic production data.

[0038] While FIG. 1-4 shows a configuration of components, other configurations may be used without departing from the scope of the disclosure. For example, various components may be combined to create a single component. As another example, the functionality performed by a single component may be performed by two or more components.

[0039] FIGs 5-7 show flowcharts in accordance with one or more embodiments. While the various blocks in this flowchart are presented and described sequentially, one of ordinary skill will appreciate that at least some of the blocks may be executed in different orders, may be combined or omitted, and at least some of the blocks may be executed in parallel. Furthermore, the blocks may be performed actively or passively. For example, some blocks may be performed using polling or be interrupt driven in accordance with one or more embodiments of the disclosure. By way of an example, determination blocks may not require a processor to process an instruction unless an interrupt is received to signify that condition exists in accordance with one or more embodiments of the disclosure. As another example, determination blocks may be performed by performing a test, such as checking a data value to test whether the value is consistent with the tested condition in accordance with one or more embodiments of the disclosure.

[0040] FIG. 5 shows a flowchart for generating synthetic control parameter sets in accordance with one or more embodiments. In Block 501, the control parameters are identified. As discussed above, the control parameters are the portions of the field that may be controlled for performing a particular field operation. Thus, the control parameters that are identified may be based on the type of field operation being performed. If at least some actual control parameter values exist for a particular control parameter set, then the identified control parameters may be the remaining control parameters to augment the actual control parameter values.

[0041] In Block 503, the valid ranges of the identified control parameters are identified to generate a multidimensional space. The valid range may be defined for a particular control parameter by determining the global set of values that the control parameter may be. For example, a manufacturer of a piece of field equipment may have a particular acceptable range by which the field equipment will not fail. By accessing a knowledgebase for the piece of field equipment that defines the acceptable range, the control parameter valid range for setting the piece of field equipment may be determined. By way of another example, the operator may have a particular range or set of values for a control parameter from which the operator has not deviated in the past. Accessing historical data for the operator and tabulating the values used may be performed to determine the operator's valid range. In some embodiments, a margin of error may be added to the operator's valid range to increase the range and allow for some deviation from the range. Other techniques for determining the valid range may be performed without departing from the scope of the claims. The combination of the valid ranges for each of the global variables may be a multidimensional space.

[0042] In Block 505, the multidimensional space is sampled one or more times to obtain one or more control parameter values. In one or more embodiments, the sampling may be performed randomly, pseudo-randomly, probabilistically, or using any sampling technique. Further, the sampling may be performed multiple times to generate multiple control parameter data sets. Further, if actual control parameters are used in addition to synthetic, the actual control parameters may be combined with the sampled control parameters to generate a semi-actual and semi-synthetic control parameter set.

[0043] Although not shown in FIG. 5, another technique for generating synthetic control parameter sets may be to perturb actual control parameter values. For example, the perturbing may be performing by modifying the value of one or more control parameters in an actual control parameter set to generate at least partially synthetic control parameter set. The amount of the modification may be dependent on the control parameter. In some embodiments, the larger the valid range, the greater the modification when perturbing the control variable value. In other words, the amount of change of the control variable value from the actual control variable value may be proportional to the valid range.

[0044] Using a synthetic and/or actual control parameter set, the field simulator may generate synthetic production data set, which is used to train a field statistical model. FIG. 6 shows a flowchart for training the field statistical model using a control parameter set in accordance with one or more embodiments. In Block 601, a control parameter set for the field is obtained in accordance with one or more embodiments. Obtaining the control parameter set may be performed by obtaining actual control parameter set from a data repository and/or performing the operations discussed above with reference to FIG. 5.

[0045] In Block 603, production is simulated using a field simulator on the control parameter set to generate a production data set matching the control parameter set. In other words, the control parameter set is used as input to the field simulator. The field simulator models uses the values in the control parameter set to model the rock mechanics of the underground formations, the movement of hydrocarbons, and other aspects of production. In other words, the field simulator may model the various innate forces and forces caused by the control parameter set to calculate the production data set.

[0046] In Block 605, a field statistical model is trained using the control parameter set and the production data set in accordance with one or more embodiments. In other words, using multiple statistically significant corresponding control parameter sets and production data sets, the field statistical model may be generated. Generating the field statistical model may be performed, for example, by using machine learning algorithms, neural networks, decision trees, random forests, associations and sequence discovery, gradient boosting and bagging, support vector machines, nearest neighbor mapping, k-means clustering, Bayesian networks, other techniques, or a combination of techniques.

[0047] Further, although not shown in FIG. 6 as new control parameter sets and corresponding production data sets are added, based on being actual obtained information and/or synthetically generated, Block 605 may be performed to continue to train the field statistical model. Thus, the field statistical model may continually be improved with new information.

[0048] FIG. 7 shows a flowchart for using the field statistical model in accordance with one or more embodiments. In Block 701, a control parameter set for a field may be obtained. For example, an operator of the field may want to know hypothetically how a particular control parameter set may affect production. In such a scenario, the operator may provide the user interface with a control parameter set. In another example, the operator may have various options for control parameter sets and may want to determine an optimal option. By way of another example, the operator may have the field equipment configured according to a control parameter set and may want to know the expected outcome or current state. In such a scenario, the operator may provide an actual control parameter set.

[0049] The control parameter set may be provided, directly or indirectly, explicitly or implicitly, through a user interface. In some embodiments, the control parameter set may be provided through an application programming interface from another program. In some embodiments in which at least a part of the control parameter set is actual, the control parameter set may be gathered from the equipment located in the field, such as from the controllers on the equipment.

[0050] In Block 703, a request is received for a production data set in accordance with one or more embodiments. The request may be received implicitly or explicitly, directly or indirectly. For example, the request may be received by selecting a user interface widget in the graphical user interface.

[0051] In Block 705, the field statistical model is executed on the control parameter set to obtain a corresponding production data set in accordance with one or more embodiments. In other words, the control parameter set is used in a multivariate statistical analysis to determine the production data set. In some embodiments, because the production data set is Block 705 is generated based on statistics rather than field simulations, the number of calculations may be reduced. Thus, the production data set, in some embodiments, may be acquired faster than by using the field simulator. Thus, the operator may be informed quicker as to the outcome of using a particular control parameter set.

[0052] In Block 707, the production data set is presented in accordance with one or more embodiments. For example, the production data set may be displayed in a graphical user interface, transmitted to a user, stored, or otherwise presented.

[0053] In Block 709, a field operation is performed based on the production data set in accordance with one or more embodiments. For example, performing the field operation may be transmitting a control signal to the equipment located at the field, changing the state of the equipment or production operations being performed at the field, or performing any other action that affects the gathering of hydrocarbons.

[0054] While the blocks of FIG. 7 are being performed, the field simulator may use the control parameter set from Block 701 to independently create a production data set. The independent production data set may be used to further train the field statistical model and/or to confirm the accuracy of the field statistical model. However, because the operations of the field simulator may be performed offline, the operator may determine whether to use the field control parameter set based on the results of Block 705 without waiting for the field simulator to complete operations in accordance with one or more embodiments.

[0055] While the disclosure has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the disclosure as disclosed herein. Accordingly, the scope of the technology should be limited only by the attached claims.

CLAIMS

What is claimed is:

1. A method for production analysis using data analytics comprising:
   obtaining a first control parameter set for a field;
   simulating production using a field simulator on the first control parameter set to generate a first production data set matching the first control parameter set;
   training a field statistical model using the first control parameter set and the first production data set;
   obtaining a second control parameter set;
   executing the field statistical model on the second control parameter set to obtain a second production data set defining a production in the field; and
   presenting the second production data set.

2. The method of claim 1, further comprising:
   performing, using equipment at the field, a production operation according to the second control parameter set.

3. The method of claim 1, further comprising:
   simulating production using the field simulator on the second control parameter set to generate a third production data set matching the second control parameter set; and
   updating the field statistical model using the second control parameter set and the third production data set.

4. The method of claim 3, further comprising:
   calculating a difference between the second production data set and the third production data set,
   wherein the field statistical model is updated in response to the difference failing to satisfy a threshold.

5. The method of claim 1, wherein the first control parameter set comprises actual data used in a production operation at the field.

6. The method of claim 5, further comprising:

   perturbing the actual data to generate synthetic control parameter set; and

   simulating production using a field simulator on the synthetic control parameter set to generate a third production data set matching the synthetic control parameter set,

   wherein training the field statistical model further uses the synthetic control parameter set and the third production data set.

7. The method of claim 1, wherein training the statistical model further uses third control parameter set and third production data set, wherein the third control parameter set is actual data used in a production operation at the field and the third production data set is an actual result of using the actual data in the production operation.

8. The method of claim 1, wherein the second production data set is a production profile spanning a period of time.

9. The method of claim 1, wherein the second production data set is a production amount.

10. The method of claim 1, further comprising:

    generating a multidimensional space by, for each control parameter of a plurality of control parameters, defining a valid range for the control parameter; and

    sampling the multidimensional space to generate a data set in the first control parameter set.

11. The method of claim 10, wherein, for at least one control parameter, the valid range is defined according to previous production operations performed by an operator, wherein the second production data set is obtained for the operator.

12. A system for production analysis using data analytics comprising:
    a data repository for storing field training data comprising a first control parameter set and a first production data set matching the first control parameter set; and
    a computer processor that executes:
        a field simulator that simulates production on the first control parameter set to generate the first production data set,
        a field statistical model generator that trains a field statistical model using the first control parameter set and the first production data set, and
        the field statistical model that:
            obtains a second control parameter set, and
            executes the field statistical model on the second control parameter set to obtain a second production data set defining a production in the field.

13. The system of claim 12, wherein the computer processor further executes:
    an interface that presents the second production data set.

14. The system of claim 12, wherein the computer processor further executes:
    a sampler that samples a multidimensional space to generate the first control parameter set.

15. The system of claim 12, further comprising:
    field equipment for performing a production operation at the field according to the second control parameter set.

16. A non-transitory computer readable medium for production analysis using data analytics comprising computer readable program code for:
    obtaining a first control parameter set for a field;

simulating production using a field simulator on the first control parameter set to generate a first production data set matching the first control parameter set;

training a field statistical model using the first control parameter set and the first production data set;

obtaining a second control parameter set;

executing the field statistical model on the second control parameter set to obtain a second production data set defining a production in the field; and

presenting the second production data set.

17. The non-transitory computer readable medium of claim 16, further comprising computer readable program code for:

simulating production using the field simulator on the second control parameter set to generate a third production data set matching the second control parameter set; and

updating the field statistical model using the second control parameter set and the third production data set.

18. The non-transitory computer readable medium of claim 18, further comprising computer readable program code for:

perturbing the actual data to generate synthetic control parameter set; and

simulating production using a field simulator on the synthetic control parameter set to generate a third production data set matching the synthetic control parameter set,

wherein training the field statistical model further uses the synthetic control parameter set and the third production data set.

19. The non-transitory computer readable medium of claim 16, wherein training the statistical model further uses third control parameter set and third production data set, wherein the third control parameter set is actual data used in a production operation at

the field and the third production data set is an actual result of using the actual data in the production operation.

20. The non-transitory computer readable medium of claim 16, further comprising computer readable program code for:

    generating a multidimensional space by, for each control parameter of a plurality of control parameters, defining a valid range for the control parameter;

    sampling the multidimensional space to generate a data set in the first control parameter set.

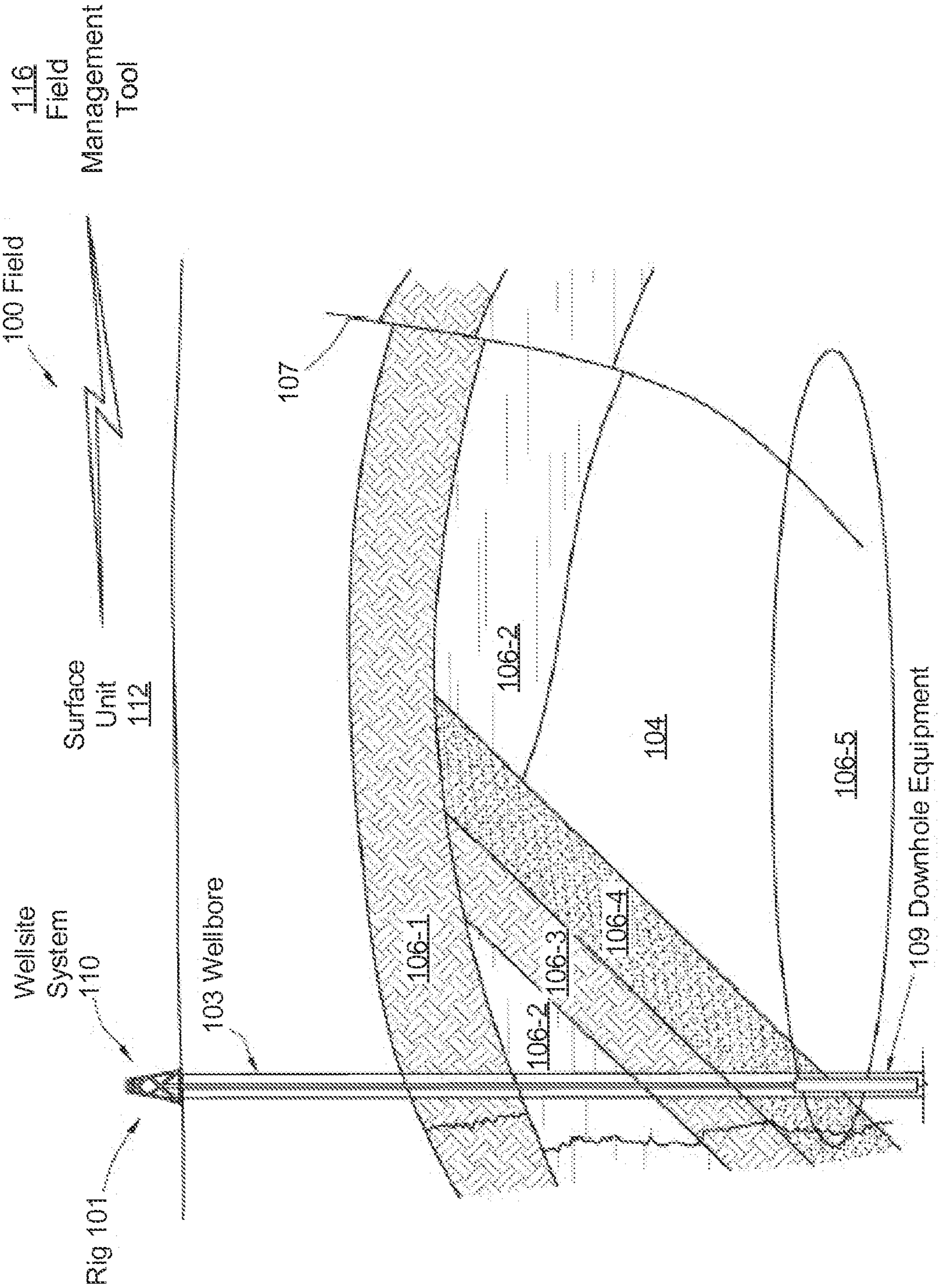
116
Field
Management
Tool
100 Field
Surface
Unit
112
Wellsite
System
110
Rig 101
103 Wellbore
107
106-1
106-2
106-2
106-3
106-4
104
106-5
109 Downhole Equipment

FIG. 1

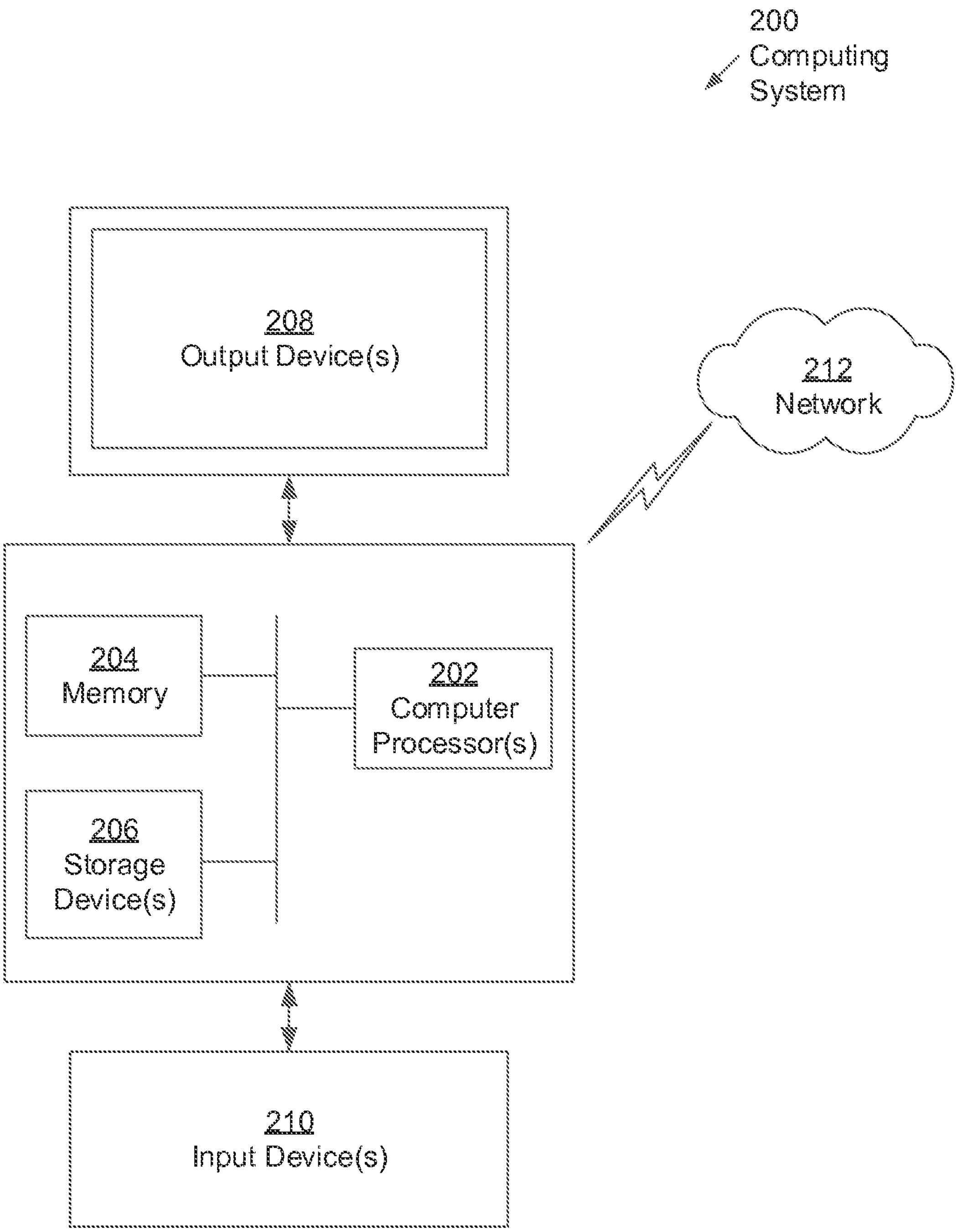
200
Computing
System
208
Output Device(s)
212
Network
204
Memory
202
Computer
Processor(s)
206
Storage
Device(s)
210
Input Device(s)

FIG. 2

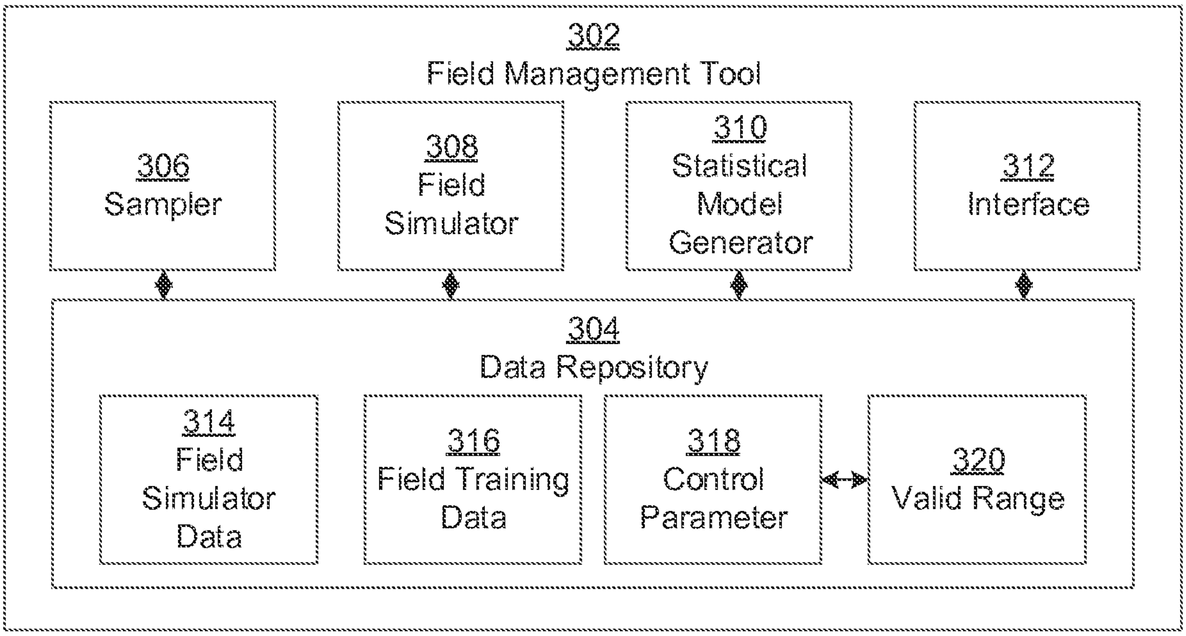
302
Field Management Tool
306
Sampler
308
Field
Simulator
310
Statistical
Model
Generator
312
Interface
304
Data Repository
314
Field
Simulator
Data
316
Field Training
Data
318
Control
Parameter
320
Valid Range

FIG. 3

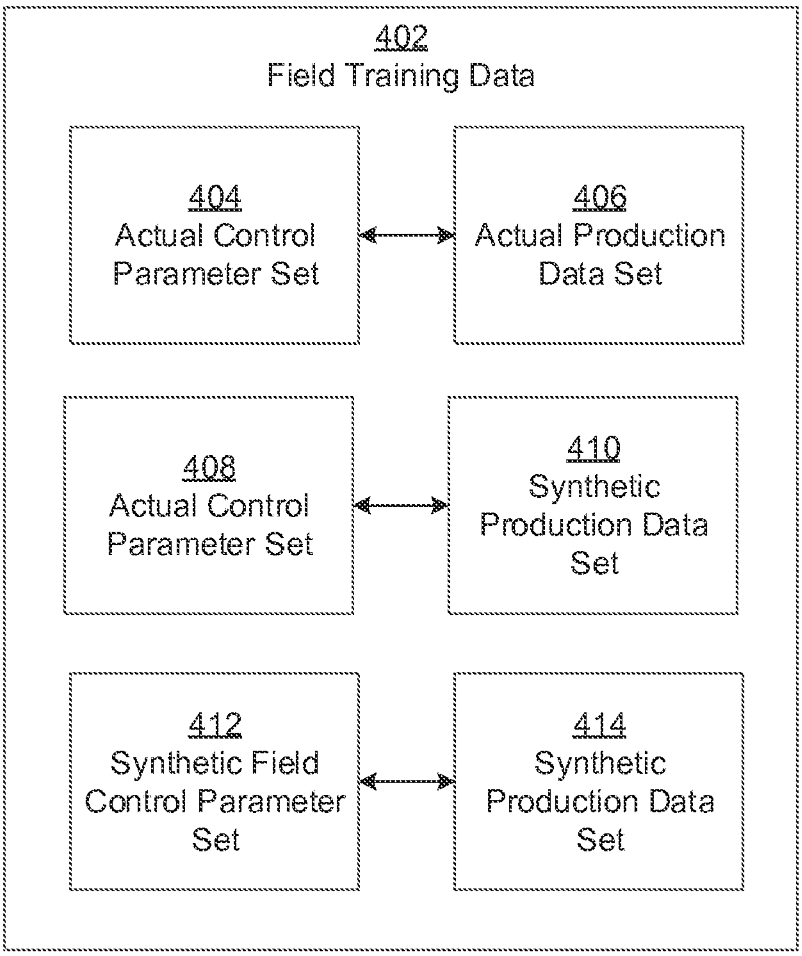
402
Field Training Data
404
Actual Control
Parameter Set
406
Actual Production
Data Set
408
Actual Control
Parameter Set
410
Synthetic
Production Data
Set
412
Synthetic Field
Control Parameter
Set
414
Synthetic
Production Data
Set

FIG. 4

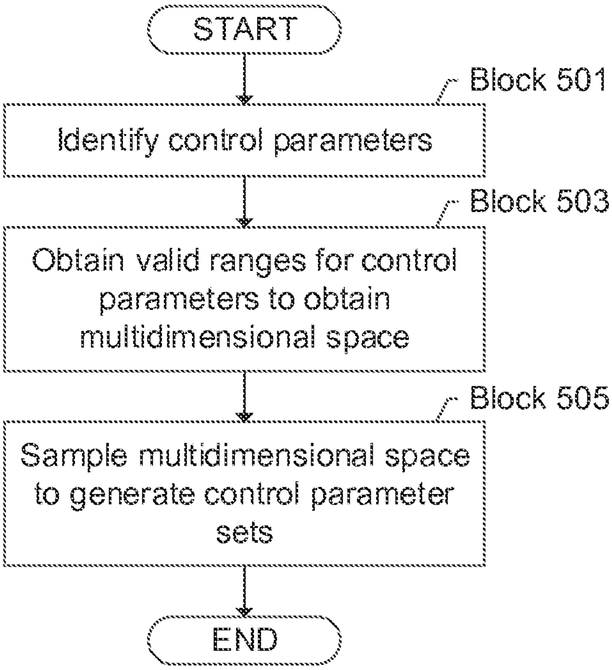
START
Block 501
Identify control parameters
Block 503
Obtain valid ranges for control parameters to obtain multidimensional space
Block 505
Sample multidimensional space to generate control parameter sets
END

FIG. 5

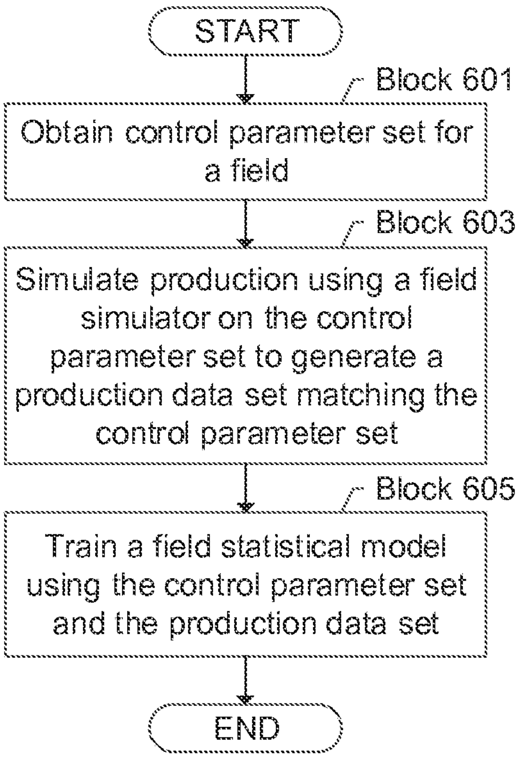
START
Block 601
Obtain control parameter set for a field
Block 603
Simulate production using a field simulator on the control parameter set to generate a production data set matching the control parameter set
Block 605
Train a field statistical model using the control parameter set and the production data set
END

FIG. 6

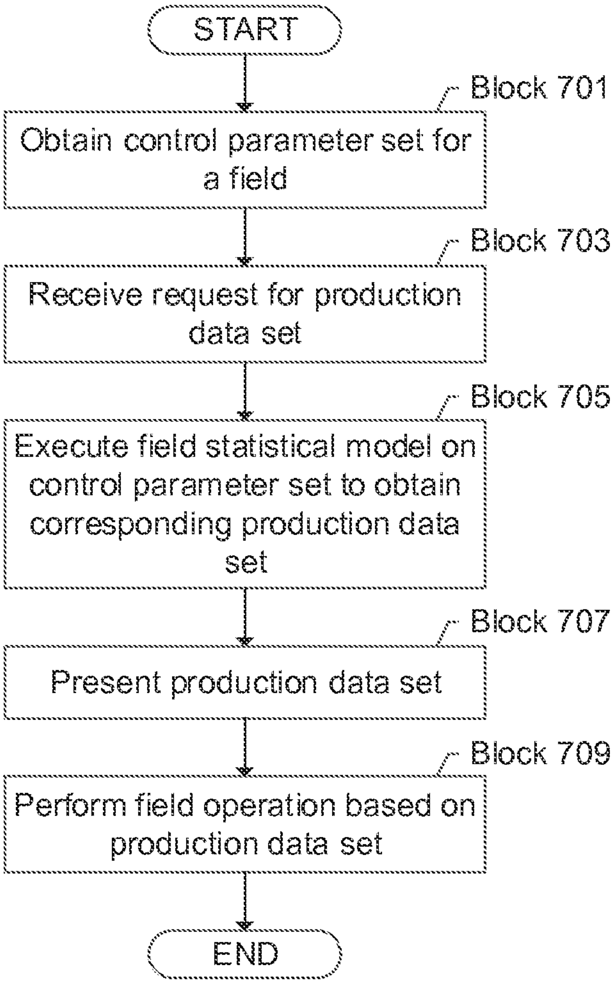
START
Block 701
Obtain control parameter set for a field
Block 703
Receive request for production data set
Block 705
Execute field statistical model on control parameter set to obtain corresponding production data set
Block 707
Present production data set
Block 709
Perform field operation based on production data set
END

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/029142

A. CLASSIFICATION OF SUBJECT MATTER

G06F 9/455(2006.01)i, E21B 47/00(2006.01)i, E21B 44/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F 9/455; G06F 17/50; G06G 7/48; E21B 43/00; G06N 99/00; G01V 1/28; E21B 47/00; E21B 44/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: production, analysis, simulation, parameter set, field, statistical model

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013-0338983 A1 (SARMA, P. et al.) 19 December 2013 See abstract; paragraphs [0091]-[0096]; and fig. 35.	1-20
A	US 2010-0179797 A1 (CULLICK, A. S. et al.) 15 July 2010 See abstract; paragraphs [0033]-[0050]; and figs. 1 and 2.	1-20
A	US 2007-0203681 A1 (EYVAZZADEH, R. Y. et al.) 30 August 2007 See abstract; paragraphs [0042]-[0051]; and fig. 1.	1-20
A	US 2013-0096898 A1 (USADI, A. et al.) 18 April 2013 See abstract; paragraphs [0066]-[0079]; and figs. 3 and 4.	1-20
A	US 2007-0005253 A1 (FORNEL, A. et al.) 04 January 2007 See abstract; claim 1; and fig. 1.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 January 2016 (29.01.2016)	**01 February 2016 (01.02.2016)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/029142

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		NO 20083577 A	19/11/2008
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		WO 2007-100827 A2	07/09/2007
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		EP 2599029 A4	08/01/2014
		WO 2012-015515 A1	02/02/2012
US 2007-0005253 A1	04/01/2007	EP 1728967 A1	06/12/2006
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		US 7752022 B2	06/07/2010