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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte XIAOHUI WU, DACHANG LI, ROSSEN PARASHKEVOV, ADAM K. USADI, and YAHAN YANG

Appeal 2017-008964
Application 13/392,035
Technology Center 2100

Before ROBERT E. NAPPI, DAVID M. KOHUT, and LYNNE E. PETTIGREW, *Administrative Patent Judges*.

PETTIGREW, *Administrative Patent Judge*.

DECISION ON APPEAL

This is an appeal under 35 U.S.C. § 134(a) from a final rejection of claims 1, 3–17, 19, and 20. We have jurisdiction under 35 U.S.C. § 6(b).

We affirm.

STATEMENT OF THE CASE[1]

Introduction

Appellants' invention is directed to a method and system to decrease the number of simulations that may be run to generate a model for predicting the properties of a hydrocarbon reservoir. Spec. ¶ 2.

Claim 1 is illustrative of the invention and is reproduced below.

> 1. A method for improving hydrocarbon production by lowering computational costs of multiple simulations, comprising:
>
> > using a computer program product, comprising a computer usable medium having a computer readable program code embodied therein, said computer readable program code adapted to be executed to implement a method comprising:
> >
> > identifying a lowest level training set (TS^1) in a lowest level physics based surrogate (PBM^1), wherein identifying TS^1 comprises:
> >
> > > sampling a parameter space to obtain a first set of sample points;
> > >
> > > evaluating a response for PBM^1 at each of the sample points;
> > >
> > > training a data fit surrogate (DFS^0) over the parameter space using the response at each of the sample points; and

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[1] Our Decision makes reference to Appellants' Reply Brief ("Reply Br.," filed June 6, 2017) and Appeal Brief ("App. Br.," filed January 26, 2017), and the Advisory Action ("Adv. Act.," mailed October 26, 2016), Examiner's Answer ("Ans.," mailed April 6, 2017), and Final Office Action ("Final Act.," mailed July 14, 2016).

identifying a second set of sample points at TS^1, wherein a response of the DFS^0 exhibits a critical behavior at the sample points;

generating at least one higher level training set (TS^k) for at least one higher level PBM^k, wherein $1 < k < K$, and wherein K represents a highest level; and

training the at least one higher level PBM^k at TS^k using a next higher level physics based surrogate (PBM^{k+1});

generating a model for predicting the properties of a hydrocarbon reservoir using at least in part a result obtained by training the at least one higher level PBM^k at TS^k, wherein one or more lower level surrogates are used to evaluate an entire parameter space for the model; and

using the model in performance planning of a hydrocarbon reservoir, enhancement of a hydrocarbon reservoir, or a combination thereof.

Rejections on Appeal

The Examiner rejected claims 1, 3–14, 17, 19, and 20 under 35 U.S.C. § 103(a) as unpatentable over Forrester (A. I. J. Forrester et al., *Recent advances in surrogate based optimization* in 45 PROGRESS IN AEROSPACE SCIENCES, 50–79 (2009)) in view of Wu (X. H. Wu et al., *Reservoir Modeling with Global Scaleup*, SOCIETY OF PETROLEUM ENGINEERS 105237, 15TH SPE MIDDLE EAST OIL & GAS SHOW AND CONF., 1–13 (2007)).

The Examiner rejected claim 15 under 35 U.S.C. § 103(a) as unpatentable over Forrester, Wu, and Badru (O. Badru & C. S. Kabir, *Well*

Placement Optimization in Field Development, SPE ANNUAL TECHNICAL CONFERENCE AND EXHIBITION, 1–9 (2003)).

The Examiner rejected claim 16 under 35 U.S.C. § 103(a) as unpatentable over Forrester, Wu, and Altamira (US 3,554,282 issued Jan. 12, 1971).

Issues on Appeal

The issues in this appeal are:

Did the Examiner err in finding that it would have been obvious to combine Forrester and Wu and further to combine Forrester and Wu with either Badru or Altamira? App. Br. 10–13; Reply Br. 5.

Did the Examiner err in rejecting independent claim 1, and similarly independent claims 14 and 17, under 35 U.S.C. § 103(a) because the combination of Forrester and Wu fails to teach or suggest "identifying a lowest level training set (TS^1) in a lowest level physics based surrogate (PBM^1), wherein identifying TS^1 comprises: sampling a parameter space to obtain a first set of sample points; evaluating a response for PBM^1 at each of the sample points; training a data fit surrogate (DFS^0) over the parameter space using the response at each of the sample points; and identifying a second set of sample points at TS^1, wherein a response of the DFS^0 exhibits a critical behavior at the sample points; [and] generating a model for predicting the properties of a hydrocarbon reservoir using at least in part a result obtained by training the at least one higher level PBM^k at TS^k, wherein one or more lower level surrogates are used to evaluate an entire parameter space for the model"? App. Br. 7–10; Reply Br. 2–4.

ANALYSIS

For all of the proposed combinations of references, Appellants argue that the Examiner impermissibly relied on hindsight, because the references are directed to different technical problems, and, therefore, the record remains unclear as to how and why the references would be combined. App. Br. 10, 11, 13.

We are not persuaded by Appellants' argument, which too narrowly defines the particular problem addressed in the references. "Whether a reference in the prior art is 'analogous' is a fact question." *In re Clay*, 966 F.2d 656, 658 (Fed. Cir. 1992) (citing *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1568 n.9 (Fed. Cir. 1987)). Two criteria have evolved for answering the question: "(1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the inventor's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved." *Id.* at 658–59 (citing *In re Deminski*, 796 F.2d 436, 442 (Fed. Cir. 1986); *In re Wood*, 599 F.2d 1032, 1036 (CCPA 1979)). Appellants' invention involves techniques to decrease the number of full physics simulations that may be run to generate a model for predicting the properties of a hydrocarbon reservoir. *See* Spec. ¶ 2. Therefore, the references that deal with surrogate/modelling based analysis are reasonably pertinent to the particular problem with which the inventor is involved because the references logically would have commended themselves to the attention of one considering the invention as a whole. *See* Final Act. 6, 15, 16. Thus, Appellants' hindsight argument is unpersuasive because it is based on the incorrect conclusion that the references are non-analogous rather than explaining why the Examiner's articulated reasoning does not support the conclusion of obviousness.

Regarding independent claims 1, 14, and 17, the Examiner finds Forrester teaches sampling a parameter space to obtain a first set of sample points (initial samples (Final Act. 3; Adv. Act. 2; Ans. 5)); evaluating a response for the lowest level physics based surrogate at each of the sample points (true function evaluation (Final Act. 4; Ans. 3)); training a data fit surrogate (Kriging model) over the parameter space using the response at each of the sample points (refitting the surrogate to the data (Final Act. 4; Adv. Act. 2; Ans. 5)); and identifying a second set of sample points as a lowest level training set (initial samples and infill points (Final Act. 4; Ans. 4)), wherein a response of the data fit surrogate exhibits a critical behavior at the sample points (infill points used to isolate a local minimum (Final Act. 4; Ans. 4–5)); and generating a model for predicting properties using at least in part a result obtained by training the at least one higher level physics based surrogate at a higher level training set, wherein one or more lower level surrogates are used to evaluate an entire parameter space for the model (exploration-based infill (Final Act. 5 (citing Forrester p. 68, ¶ 2 "Exploration-based infill has its niche in design space visualization and comprehension where the object is to build an accurate approximation of the entire design landscape to help the designer visualize and understand the design environment they are working in."))).

Appellants contend that the Examiner erred in finding the combination of Forrester and Wu teaches or suggests the limitations of claim 1. App. Br. 6–9. Specifically, Appellants argue Forrester does not start with simulations at the lowest level surrogate, but begins with calculations at the highest level (expensive data) and evaluates the surrogate, and then uses calculations at the lower levels (cheap data) to correct the surrogate. App. Br. 7–9. Appellants further argue the Examiner misconstrued Forrester's surrogate as the physics based surrogate when it is the data fit surrogate. App. Br. 9; Reply. Br. 3. Appellants argue Wu does not cure the deficiencies of Forrester. App. Br. 9.

Appellants' arguments do not persuade us of error with respect to the Examiner's findings concerning Forrester. The Examiner finds Forrester's surrogate optimization is the same as the claimed "identifying a lowest level training set" (sampling, evaluating, training), where the optimization is done using a physics based surrogate corrected with a data fit surrogate, as claimed. Ans. 3–4. The Examiner finds the multi-fidelity analysis method of co-Kriging takes advantage of using a physics based surrogate model and the data fit surrogate model, using expensive data (calls to the true function) and cheap data (the physics based surrogate) in the correction process. *See* Final Act. 4; Adv. Act. 3; Ans. 4–5. We also note that Forrester teaches space-mapping in addition to co-Kriging as a multi-fidelity analysis method, another physics based surrogate method. Forrester § 3.7.2 (citing Bandler J, Cheng Q, Dakroury S, Mohamed A, Bakr M, Madsen K, et al. *Space mapping: the state of the art*, IEEE Transactions on Microwave Theory and Techniques 2004: 52: 337–61). Thus, the weight of the evidence supports the Examiner's findings that the surrogate in Forrester is a lower level physics based surrogate and with each interpolation of the surrogate model (data fit surrogate), the surrogate will be refitted to the data interpolated at the initial sample points until the surrogate is optimized to a higher level surrogate for use in generating a model for predicting properties, as claimed.

Accordingly, Appellants have not persuaded us that the Examiner erred in finding the combination of Forrester and Wu teaches or suggests the limitations as recited in claim 1 and similarly required in claims 14 and 17. Claims 3–13, 19, and 20 depend from one of claims 1, 14, and 17 and are not argued separately. We sustain the Examiner's rejection of claims 1, 3–14, 17, 19, and 20 under 35 U.S.C. § 103(a) as unpatentable over Forrester and Wu.

Regarding the rejection of claims 15 and 16, Appellants present arguments that Badru and Altamira do not remedy the deficiencies of Forrester and Wu. App. Br. 10–13. As we find no deficiencies in the Examiner's rejection of independent claims 1, 14, and 17 as unpatentable over Forrester and Wu for the reasons discussed above, we likewise sustain the Examiner's rejection of claim 15 under 35 U.S.C. §103(a) as unpatentable over the combination of Forrester, Wu, and Badru and the Examiner's rejection of claim 16 under 35 U.S.C. §103(a) as unpatentable over the combination of Forrester, Wu, and Altamira.

CONCLUSION

On the record before us, Appellants have not persuaded us that the Examiner erred in rejecting claims 1, 3–17, 19, and 20 under § 103(a) as unpatentable over the combinations of cited references.

DECISION

The Examiner's rejections of claims 1, 3–17, 19, and 20 are affirmed.

AFFIRMED