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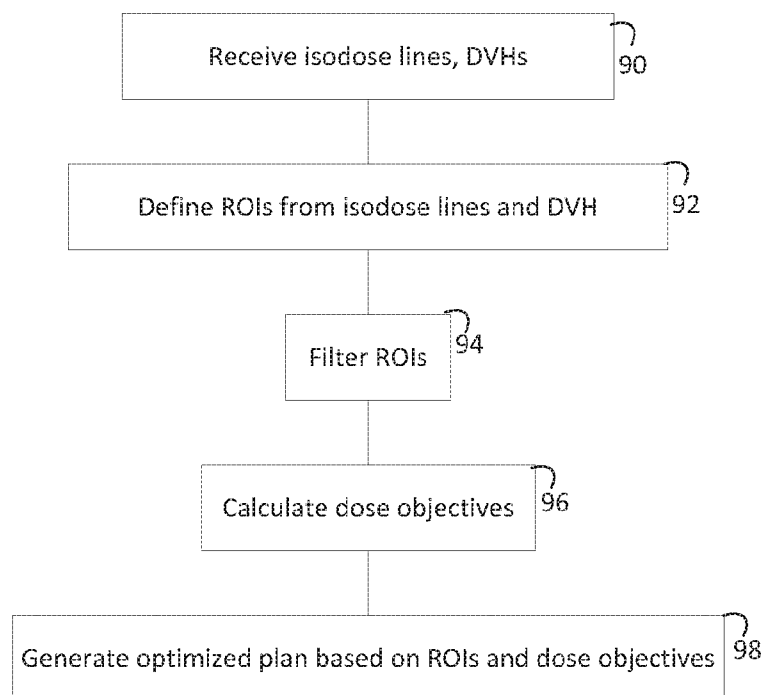
FIGURE 5

(57) **Abstract**: A radiation therapy planning
system (10) includes an isodose line unit (36),
a region of interest unit (52), and an optimiz-
ation unit (58). The isodose line unit (36) re-
ceives isodose lines planned for a volume of a
subject. The region of interest unit (52)
defines at least one isodose region of interest
based on the received isodose lines. The op-
timization unit (58) generates an optimized
radiation therapy plan based on the at least
one defined isodose region of interest and at
least one dose objective for the defined region
of interest.

MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

ISODOSE OPTIMIZATION

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The following relates generally to radiation therapy planning. It finds particular application in conjunction with isodose optimization in Intensity Modulated Radiation Therapy (IMRT) or in Volumetric Modulated Arc Therapy (VMAT), and will be described with particular reference thereto. However, it will be understood that it also finds application in other usage scenarios and is not necessarily limited to the aforementioned application.

A goal of radiation therapy is to deliver lethal doses of radiation to a target area or tumor while minimizing radiation to other areas especially nearby organs or organs at risk (OARs). IMRT and VMAT are specific approaches to developing radiation therapy plans that deliver radiation doses with precisely delivered beams of external radiation to a target area of a subject. IMRT is based on a point and shoot approach for one or more discrete beam angles while VMAT is based on delivery of moving beams or arcs of radiation.

An initial or ideal plan developed with IMRT includes measuring the beams of radiation at the output of a beam of radiation in a grid format (x,y) for each angle and intensity. A fluence map can be used to describe the radiation output intensity pattern delivered at each angle for each grid. Radiation beams are straight linear projections, but do include a scatter effect in a subject volume. The impact of the fluence or radiation as measured on a subject can be represented as a three dimensional dose cloud. A dose cloud is typically viewed as isodose lines superimposed on a subject image such as a X-ray Computed Tomography (CT) image. The isodose lines provide a spatial relationship between the dose and the target and/or OARs or anatomical structures visible in the image. Another technique which illustrates the impact of the fluence is a dose volume histogram (DVH) which provides a summary of 3-dimensional (3D) dose distributions in a 2-dimensional (2D) graphical format. The DVHs show the relationship between the volume of structures such as OARs and dose. Other approaches to radiation therapy are also evaluated visually with isodose lines and DVHs.

Methods exist to implement IMRT and VMAT approaches as deliverable radiation therapy plans. The methods can include fluence optimization, conversion to machine deliverable segments for use by a radiation delivery device such as a Linear

Accelerator (LINAC), and in some cases optimization of the segments by a machine parameter optimizer. A LINAC produces beams of radiation which are collimated by a multi-leaf collimator (MLC). The MLC contains pieces of radiation absorbing material which are movable to block portions of the beam and therefore adjust the shape of the delivered radiation beam. An optimized plan includes instructions for segments of quantified beam quantity that is commonly referred to as Monitor Units or measured in Bq, and beam shapes determined by the shape formed by the MLC. Fluence optimization or generation of a fluence based plan typically proceeds creation of a deliverable plan. The dose cloud for a fluence based plan can differ from a dose cloud for the fluence plan converted to deliverable segments even if the segments are optimized by a machine parameter optimizer after conversion. Existing optimizers are designed to work with a set of objectives such as maximizing a dose to a tumor volume and minimizing a dose to OARs. Optimizers can construct a deliverable plan, subject to constraints, based on the objectives such as maximum/minimum dose for the tumor volume or OARs respectively and typically work directly with information from the various approaches such as IMRT. The shortcoming of this approach is that only the 2D DVH information is optimized by the machine parameter optimizer. The 3D dose cloud information is not considered by the machine parameter optimizer.In effect, two or more independent volume elements in the 3D dose cloud can map to a single objective point in the 2D DVH, and this leads to a loss of spatial specificity of 2D DVH-based objectives.

The following discloses a new and improved method for including 3D dose information in the machine parameter optimization which addresses the above referenced issues, and others.

In accordance with one aspect, a radiation therapy planning system includes an isodose line unit, a region of interest unit, and an optimization unit. The isodose line unit receives isodose lines planned for a volume of a subject. The region of interest unit defines at least one isodose region of interest based on the received isodose lines. The optimization unit generates an optimized radiation therapy plan based on the at least one defined region of interest and at least one dose objective for the defined region of interest.

In accordance with another aspect, a method of radiation therapy planning includes receiving isodose lines planned for a volume of a subject. At least one isodose region of interest is defined based on the received isodose lines. An optimized radiation therapy plan is generated based on the defined at least one isodose region of interest and at least one dose objective for the defined at least one isodose region of interest.

In accordance with another aspect, a radiation therapy planning system includes a display device, at least one input device, and one or more processors. The one or more processors are configured to receive planned isodose lines corresponding to a subject volume and visualize the planned isodose lines superimposed on an image of the subject volume on the display device. The one or more processors are further configured to receive selections of the visualized planned isodose lines from the at least one input device, define at least one isodose region of interest which includes the voxels delineated by the selected isodose lines, and calculate at least one dose objective based on the selected isodose lines. The one or more processors are further configured to generate an optimized deliverable radiation therapy plan based on the defined at least one isodose region of interest and the calculated at least one dose objective.

One advantage is that customizations based on radiation therapy plan visualizations are incorporated into an optimized radiation therapy plan.

Another advantage resides in combining visualized spatial changes and/or dose volume changes into the radiation therapy planning process.

Another advantage resides in customizing radiation therapy plans based on healthcare practitioner input or specific patient knowledge.

Another advantage resides in the dose optimization which can be delineated at the voxel level.

Another advantage resides in the creation of a deliverable plan based on either an IMRT or VMAT approach.

Still further advantages will be appreciated to those of ordinary skill in the art upon reading and understanding the following detailed description.

The invention may take form in various components and arrangements of components, and in various steps and arrangement of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIGURE 1 schematically illustrates an embodiment of an isodose optimization system.

FIGURE 2 illustrates a prior art exemplary visualized DVHs.

FIGURE 3 illustrates a prior art exemplary visualized fluence map.

FIGURE 4 illustrates an exemplary visualized isodose ROI.

FIGURE 5 flowcharts one method of isodose optimization.

With reference to FIGURE 1, an embodiment of an isodose optimization system **10** is schematically illustrated. The system can receive planned isodose lines **12** and/or dose volume histograms (DVHs) **14** for a volume **16** of a subject **18** based on an initial or ideal plan **20** based on an IMRT approach, VMAT approach, and the like, or the system can construct the isodose lines **12** and/or DVHs **14** from IMRT or VMAT information such as a dose distribution created from fluence maps. The system can receive or construct a planning image **22** such as a CT image from a CT image device **24** which corresponds to the subject volume. The optimized plan **26** includes control instructions for a radiation therapy delivery device **28** such as a LINAC. The radiation delivery device **28** includes a control **30** which executes the control instructions according to the radiation therapy plan to deliver radiation to targeted volumes of a subject. The control signals control the radiation therapy device delivery of external beams of radiation that can include a step and shoot technique or a continuous movement (dynamic) technique. The control sequences can include beam-on time, beam angle position, beam delivery rate, and instructions to shape the beam during those segments. The shape of the beam **32,** represented in a 2D grid format in an exploded perspective view, is formed by movement of leaves in a multi-leaf collimator (MLC) **34** of the radiation delivery device **28** and controlled by a control **30**.

The system **10** includes an isodose line unit **36** which receives or constructs isodose lines planned for the subject volume **16**. The isodose lines **12** can be received in an image format, a numerical format, coordinate format, and the like. The isodose lines **12** can be constructed from a source dose grid from an approach such as fluence maps from an IMRT approach. The source dose grid can include different treatment modalities such as proton therapy or brachy therapy. The system includes a dose volume histogram (DVH) unit **38** which receives or constructs DVHs from a source dose grid planned for the subject volume **16**. The isodose lines **12** and DVHs **14** can be stored in data stores. A data store can include a computer memory such as disk, flash storage, and the like and organization such as a file system, directory system, database, and the like.

The system **10** includes a user interface **40** which visualizes the constructed or received DVHs **16** and the constructed or received isodose lines **14** superimposed on the corresponding image **22**. The user interface allows a healthcare practitioner to modify either of the visualized DVHs or the visualized isodose lines. A display device **42** such as a screen of a computing device **44** displays the visualized DVHs and the visualized isodose lines. The computing device **44** includes one or more electronic processors **46** and at least one input

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device **48** which receives the healthcare practitioner modifications to either of the visualized DVH or the visualized isodose lines. The user interface modifies the visualized DVHs according to corresponding healthcare practitioner changes to the visualized isodose lines. The user interface modifies the visualized isodose lines according to corresponding healthcare practitioner modifications to the visualized DVHs.

The computing device **44** can be a desktop computer, a laptop, a tablet, a mobile computing device, a smartphone, and the like. The input device **48** can be a keyboard, touch screen, a mouse, a microphone, and the like. The display device **42** as used herein encompasses an output device or a user interface adapted for displaying images or data. A display may output visual, audio, and or tactile data. Examples of a display include, but are not limited to: a computer monitor, a television screen, a touch screen, Vector display, Flat panel display, Vacuum fluorescent display (VF), Light-emitting diode (LED) displays, Electroluminescent display (ELD), Plasma display panels (PDP), Liquid crystal display (LCD), Organic light-emitting diode displays (OLED), Cathode ray tube (CRT) displays, and the like.

The user interface **40** allows a user or healthcare practitioner to select isodose lines which define or delineate an isodose region of interest (ROI) **50**. A ROI unit **52** defines the isodose ROI **50** based on the selected isodose lines which are stored in a data store. Each defined isodose ROI delineates a spatial volumetric area of the subject at a voxel level. A ROI can be defined as a volume of the subject selected by an isodose level, an isodose line and/or a point of a DVH curve such as a deflection point. For example, the isodose ROI can be constructed from a volume bounded by an isodose line, a volume bounded between two isodose lines, and/or a volume outside an isodose line. The selected isodose line can be selected based on the coverage or exclusion of a target area or volume of the subject. The selected isodose line can be selected based on a uniform dose, a minimum dose, or a system or user parameter.

The system **10** can include a filter unit **54** which filters the defined ROIs or a portion thereof with a surface smoothing, combining of small neighboring curves, combining neighboring portions of expansion or contraction, and the like. In one embodiment, the filtered isodose ROIs are visualized by the user interface **40** which can be reviewed by the healthcare practitioner. The filter unit **54** can include filtering based on the characteristics of the MLC **34**. For example, the smoothing functions can be further weighted or modified by the leaf thickness.

The system **10** includes a dose objective unit **56** which calculates dose objectives for the defined isodose ROI. The calculated dose objective can include a function of the isodose lines which defined the isodose ROI. For example, a dose objective can include a minimum, maximum, or average of isodose levels associated with isodose lines which bound the isodose ROI. The dose objective can include a uniform value or a function of values based on the received or modified DVHs.

The system **10** includes an optimizer unit **58** which generates an optimized deliverable radiation therapy plan **20** based on the defined isodose ROIs **50** and the calculated at least one dose objective. The generated plan can include a uniform dose objective or minimum dose objective for the ROI inside a highest isodose line for the target volume. The generated plan can include a uniform dose objective, a minimum dose objective, or a minimum dose volume objective for the defined isodose ROI between a pair of lower isodose lines. The generated plan can include a maximum dose objective for the defined isodose ROI and/or defined ring shaped isodose ROI outside the target volume.

The various units or control **30, 36, 38, 40, 52, 54, 56,** and **58,** are suitably embodied by an electronic data processing device, such as the electronic processor or electronic processing device **46** of the computing device **44,** or by a network-based server computer operatively connected with the computing device **44** by a network, or so forth. The user interface **40** includes embodiment of the computing device **44.** Moreover, the disclosed visualization, ROI definition, and radiation therapy plan generation techniques are suitably implemented using a non-transitory storage medium storing instructions (e.g., software) readable by an electronic data processing device and executable by the electronic data processing device to perform the disclosed techniques.

With reference to FIGURE 2 an exemplary visualized integral DVHs **60** are illustrated. The DVHs can be visualized as line graphs where each line **62** represents the distribution of dose in the ROI associated with that line. Each point on the line represents dose and volume value pairs. Each point is read as the fraction of the ROI total volume receiving that amount of dose or more.. The horizontal axis includes the dose in cGy. The vertical axis includes a normalized volume such as the range 0-1. The lines can include color coding or symbols, e.g. dots, hash marks, plus signs, and the like to differentiate the different intervals. For example, a line **64** shows that a nearly an entire volume such as a target volume of the subject receives a uniform dose of just under 7000 cGy. The DVH can include a legend (not shown) for the isodose lines. The user interface **40** can allow the healthcare practitioner to modify the position of the lines such as with a "drag and drop" whereby the healthcare

practitioner uses an input device **48** such as a mouse to select a point on a line representation and by dragging the line modify the position of the line. The selected points can include deflection points **66** or other points. As the line changes, the other interval lines are modified accordingly. Furthermore, modifications to the DVHs **14** cause a corresponding modification to the isodose lines **12**.

With reference to FIGURE 3, exemplary visualized isodose lines are illustrated. The exemplary visualized isodose lines include an image of the subject such as a CT image with the isodose lines **72** superimposed on the image. In the image, the human vertebrae and spinal column are visible in light areas. A target volume **74** such as a tumor is located to the left side with isodose intervals lines indicated. The isodose lines are represented in color or with symbols. A legend is included in the upper left corner which indicates isodose intervals of 10%. The user interface **40** allows the healthcare practitioner to modify the position of the isodose lines with the input device **48** such as a computer mouse providing input to a software modification tool such as a paintbrush tool. The modification of the line position occurs with a "drag and drop," select and $\pm$ or zoom motion with arrow keys, movement of mouse wheel, or other like motion of an input device or combination of input devices. The user interface modifies the movement of the isodose lines corresponding to the DVH according to the modifications entered by the healthcare practitioner for the isodose lines. For example, the user can drag the isodose line that intersects the spinal column such that the entire spinal column is in the lower dose ROI.

FIGURE 4 illustrates an exemplary visualized isodose ROI **80**. The isodose ROI defines a volume at a voxel level. The defined isodose ROI **80** shown as a ring is constructed from a first volume **82** defined by a first isodose line subtracted from a second volume **82** defined by a second isodose line. The ring isodose ROI represents a volume of the subject bounded between two isodose lines. For example, a ring ROI can include the volume between two identified isodose levels such as 45Gy to 50Gy. The isodose ROI can be further refined by the filter unit. The ring ROI can include a uniform dose objective such as the minimum of the two identified isodose levels or 45 Gy.

FIGURE 5 flowcharts one method of isodose optimization, which can be performed by one or more processors. In a step **90**, isodose lines planned for a volume of a subject are received. Received isodose lines can include isodose lines **12** constructed by the isodose line unit **36** from planning approach information such as fluence maps. The step can include receiving or constructing DVHs **14** of the subject volume by the DVH unit **38**. The step can include visualizing the received or constructed isodose lines superimposed on an

image of the subject volume or DVHs. The step can include modification of the isodose lines and/or DVHs.

The isodose lines and/or DVHs can be modified by healthcare practitioner input through the user interface **40** such as a "drag and drop" selection and modification of isodose lines, e.g. mouse movements and/or keyboard commands. A modification to the DVHs includes a corresponding modification to the isodose lines. A modification to the isodose lines includes a corresponding modification to the DVHs. The point of selection on an isodose line, e.g. with a mouse can include a deflection point. The movement can include localized line segment manipulation parameters such as line tension, spline fitting, arc manipulation and the like which affect the degree and shape of movement and change for a dragged line. Adjusting the DVHs first is advantageous to adjust the dose in each ROI defined between adjacent isodose lines. Adjusting the isodose lines assures the various tissues have an acceptable dose level.

In a step **92**, the ROI unit **52** defines isodose ROIs based on selected isodose lines. The isodose ROIs can include a volume based on a selected isodose level or interval, e.g. the region defined between a pair of adjacent isodose lines. The selected isodose level or interval can be a system supplied parameter, default system parameter, user selected parameter, and/or user default parameter. The selected isodose level can be a function of the DVH line curves. The isodose ROIs can be selected based on coverage of a target volume such as a tumor by the isodose lines and/or voxel level changes. The selection can include input by a user or healthcare practitioner through the user interface **40**. The isodose region of interest can be defined by a volume bounded by an isodose line, a volume bounded between two isodose lines, e.g. ring region, or a volume outside a volume bounded by a isodose line.

In a step **94**, the defined isodose ROIs can be filtered by the filter unit **54**. For example, the surfaces of the defined isodose ROIs can be smoothed, small neighboring curves combined, and/or neighboring portions of expansion or contraction combined.

In a step **96**, dose objectives are added and are calculated for the defined isodose region of interest. The dose objective can include a function of isodose levels of the isodose lines used to define the isodose lines. For example, a ring shaped isodose ROI can include a minimum, maximum, or average of the isodose lines used to defined the isodose ROI. The ring shaped isodose ROI defined by a first isodose line with a level of 40 cGy and a second isodose line with a level of 45 cGy can include a dose objective calculated as min(40, 45) or 40, max(40, 45) or 45, or avg(40, 45) or 42.5, etc.

The optimization unit **58** generates a deliverable radiation therapy plan based the defined isodose ROIs in a step **98**. The generated plan can include a uniform dose objective or a minimum dose objective for the isodose ROI corresponding to a highest dose objective for a target volume. The generated plan can include a uniform dose objective, a minimum dose objective, or a minimum dose volume objective for the defined isodose ROI corresponding to a lower isodose for the target volume. The generated plan can include a maximum dose objective for a defined isodose ROI and/or defined isodose ring ROI outside the target volume. The method can include a one or more processors such as the electronic processor **46** of the computing device **44** to perform each step. The deliverable plan includes the instructions or control signals for delivery of external beams of radiation. The control signals include the amount of beam quantity such as the monitor units (MUs) or Bq's, and the control instructions to shape the MLC.

It is to be appreciated that in connection with the particular illustrative embodiments presented herein certain structural and/or function features are described as being incorporated in defined elements and/or components. However, it is contemplated that these features may, to the same or similar benefit, also likewise be incorporated in other elements and/or components where appropriate. It is also to be appreciated that different aspects of the exemplary embodiments may be selectively employed as appropriate to achieve other alternate embodiments suited for desired applications, the other alternate embodiments thereby realizing the respective advantages of the aspects incorporated therein.

It is also to be appreciated that particular elements or components described herein may have their functionality suitably implemented via hardware, software, firmware or a combination thereof. Additionally, it is to be appreciated that certain elements described herein as incorporated together may under suitable circumstances be stand-alone elements or otherwise divided. Similarly, a plurality of particular functions described as being carried out by one particular element may be carried out by a plurality of distinct elements acting independently to carry out individual functions, or certain individual functions may be split-up and carried out by a plurality of distinct elements acting in concert. Alternately, some elements or components otherwise described and/or shown herein as distinct from one another may be physically or functionally combined where appropriate.

In short, the present specification has been set forth with reference to preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the present specification. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the

appended claims or the equivalents thereof. That is to say, it will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications, and also that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are similarly intended to be encompassed by the following claims.

CLAIMS:

What is claimed is:

1. A radiation therapy planning system **(10)**, comprising:

an isodose line unit **(36)** which receives isodose lines planned for a volume of a subject;

a region of interest unit **(52)** which defines at least one isodose region of interest based on the received isodose lines; and

an optimization unit **(58)** which generates an optimized radiation therapy plan based on the at least one defined region of interest and at least one dose objective for the defined region of interest.

2. The system **(10)** according to claim 1, further including:

a dose volume histogram unit **(38)** which receives dose volume histograms planned for the subject volume; and

wherein the at least one dose objective is based on the received dose volume histograms.

3. The system **(10)** according to either one of claims 1 or 2, further including:

a user interface **(40)** which visualizes the received dose volume histograms **(14)** or the received isodose lines **(12)**, and allows a healthcare practitioner to modify one of the visualized dose volume histograms **(60)** or the visualized isodose lines **(70)**;

a display device **(42)** which displays the visualized dose volume histograms **(60)** and the visualized isodose lines **(70)**; and

at least one input device **(48)** which receives the healthcare practitioner modifications to one of the visualized dose volume histograms **(60)** or the visualized isodose lines **(70)**.

4. The system **(10)** according to any one of claims 1-3, wherein the at least one isodose region of interest includes voxels located in a volume defined by isodose lines.

5. The system **(10)** according to any one of claims 1-4, wherein the at least one isodose region of interest includes at least one of:

> a volume bounded by an isodose line;
>
> a volume bounded between two isodose lines; or
>
> a volume outside an isodose line.

5. The system according to any one of claims 1-4, wherein the at least one dose objective includes a result of a function of dose values associated with isodose lines which define the at least one isodose region of interest.

6. The system according to any one of claims 1-5, wherein the at least one dose objective includes at least one of:

> at least one of a uniform dose objective or a minimum dose objective for the at least one isodose region of interest corresponding to a highest isodose for a target volume;
>
> at least one of a uniform dose objective, a minimum dose objective, or a minimum dose volume objective for the defined at least one isodose region of interest corresponding to a lower isodose for the target volume; or
>
> a maximum dose objective for a defined at least one isodose region of interest outside the target volume.

7. The system according to any one of claims 1-6, further including:

> a filtering unit **(54)** which filters at least a portion of the defined at least one isodose region of interest based on at least one of:
>
> > smoothing the surface of the region of interest;
> >
> > combining small neighboring curves; or
> >
> > combining neighboring portions of expansion or contraction.

8. The system according to claim 7, wherein the filtering unit **(54)** filters based on characteristics of a multi-leaf collimator (MLC).

9. The system according to any one of claims 1-8, wherein the radiation therapy plan includes control signals for a radiation therapy device **(28)** to deliver external beams of radiation in either one of: a step and shoot technique, or a continuous movement technique.

10. The system according to claims 9, wherein the control signals include instructions for beam quantity and MLC shapes.

11. A method of radiation therapy planning, comprising:

   receiving **(90)** isodose lines planned for a volume of a subject;

   defining **(92)** at least one isodose region of interest based on the received isodose lines; and

   generating **(98)** an optimized radiation therapy plan based on the defined at least one isodose region of interest and at least one dose objective for the defined at least one isodose region of interest.

12. The method according to claim 11, wherein receiving further includes:

   receiving dose volume histograms planned for the subject; and

   wherein the at least one dose objective is based on the received dose volume histograms.

13. The method according to either one of claims 11 and 12, wherein receiving includes:

   visualizing the received dose volume histograms **(14)** and the received isodose lines superimposed on an image of the subject volume **(70)**; and

   modifying at least one of the visualized dose volume histograms or the visualized isodose lines.

14. The method according to any one of claims 11-13, wherein the at least one isodose region of interest includes voxels located in a volume defined by isodose lines.

15. The method according to any one of claims 11-14, wherein the at least one isodose region of interest includes at least one of:

   a volume bounded by an isodose line;

   a volume bounded between two isodose lines; or

   a volume outside an isodose line.

16. The method according to any one of claims 11-15, wherein the at least one dose objective includes at least one of:

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at least one of a uniform dose objective or a minimum dose objective for the at least one isodose region of interest corresponding to a highest isodose for a target volume;

at least one of a uniform dose objective, a minimum dose objective, or a minimum dose volume objective for the defined at least one isodose region of interest corresponding to a lower isodose for the target volume; or

a maximum dose objective for a defined at least one isodose ring region of interest outside the target volume.

17. The method according to any one of claims 11-16, further including:

filtering **(94)** at least a portion of the defined at least one isodose region of interest based on at least one of:

smoothing the surface of the at least one isodose region of interest;

combining small neighboring curves; or

combining neighboring portions of expansion or contraction.

18. A non-transitory computer-readable storage medium carrying software which controls one or more electronic data processing devices **(46)** to perform the method according to any one of claims 11-17.

19. An electronic data processing device **(46)** configured to perform the method according to any one of claims 11-17.

20. A radiation therapy planning system **(10)**, comprising:

a display device **(42)**;

at least one input device **(48)**; and

one or more processors **(46)** configured to:

receive **(90)** planned isodose lines corresponding to a subject volume;

visualize the planned isodose lines superimposed on an image of the subject volume **(70)** on the display device **(42)**;

receive selections of the visualized planned isodose lines from the at least one input device **(48)**;

define **(92)** at least one isodose region of interest which includes the voxels delineated by the selected isodose lines;

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calculate **(96)** at least one dose objective based on the selected isodose lines; and

generate **(98)** an optimized deliverable radiation therapy plan based on the defined at least one isodose region of interest and the calculated at least one dose objective.
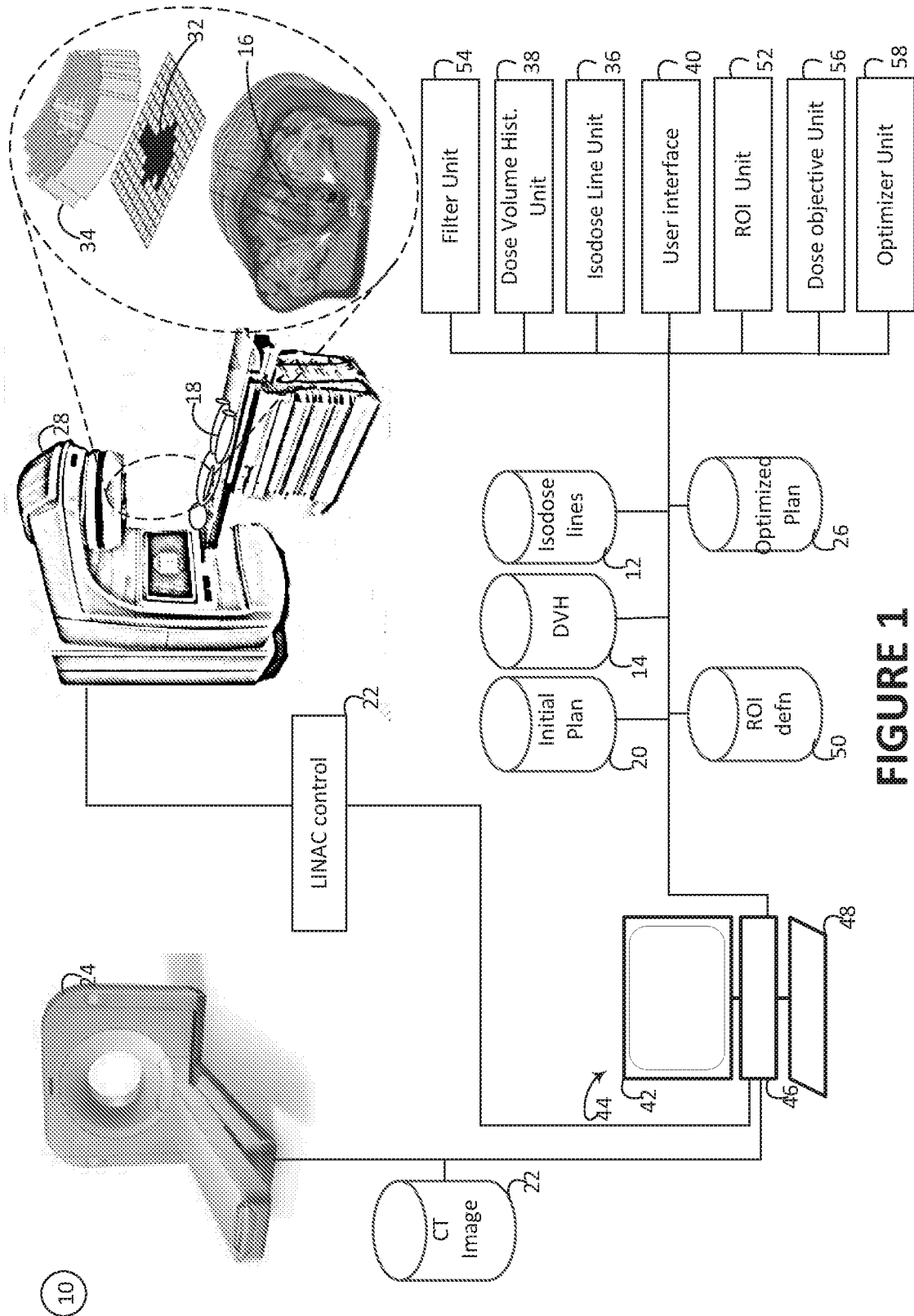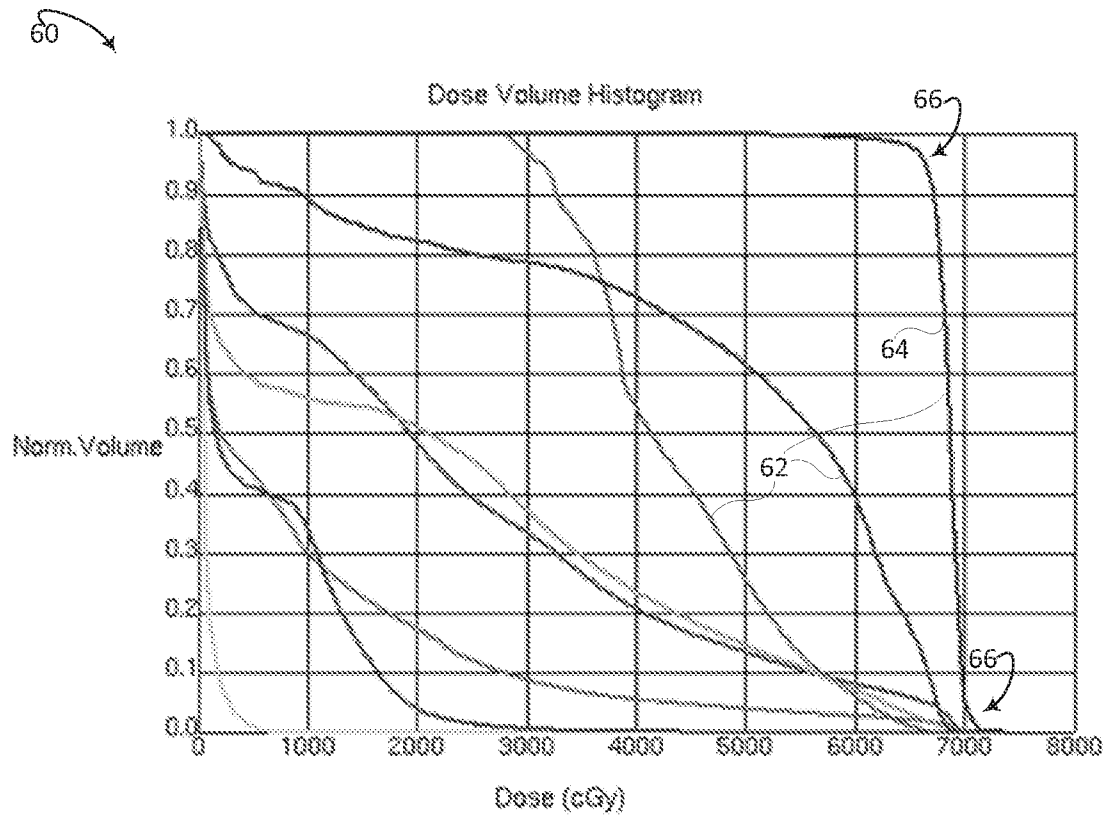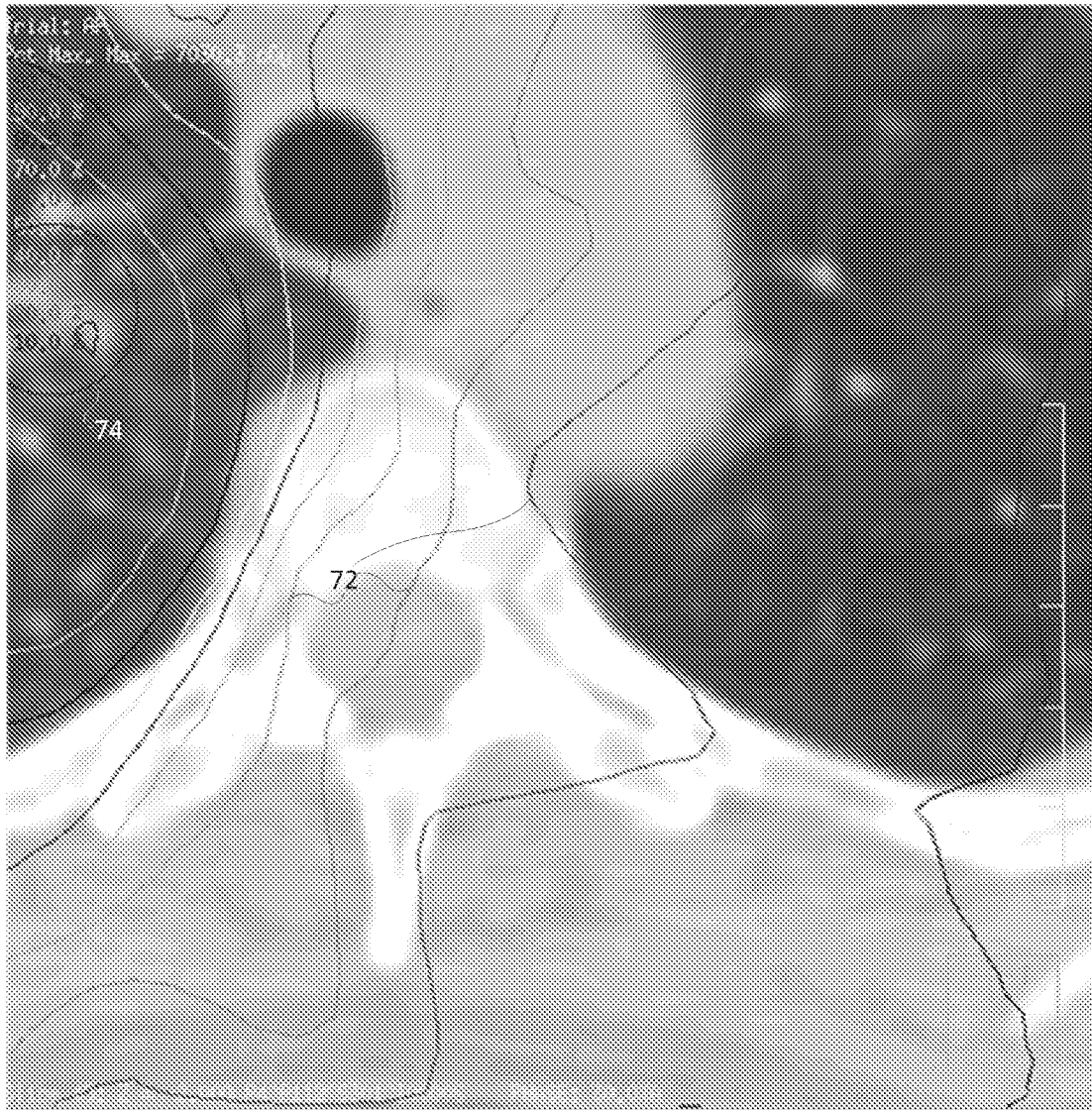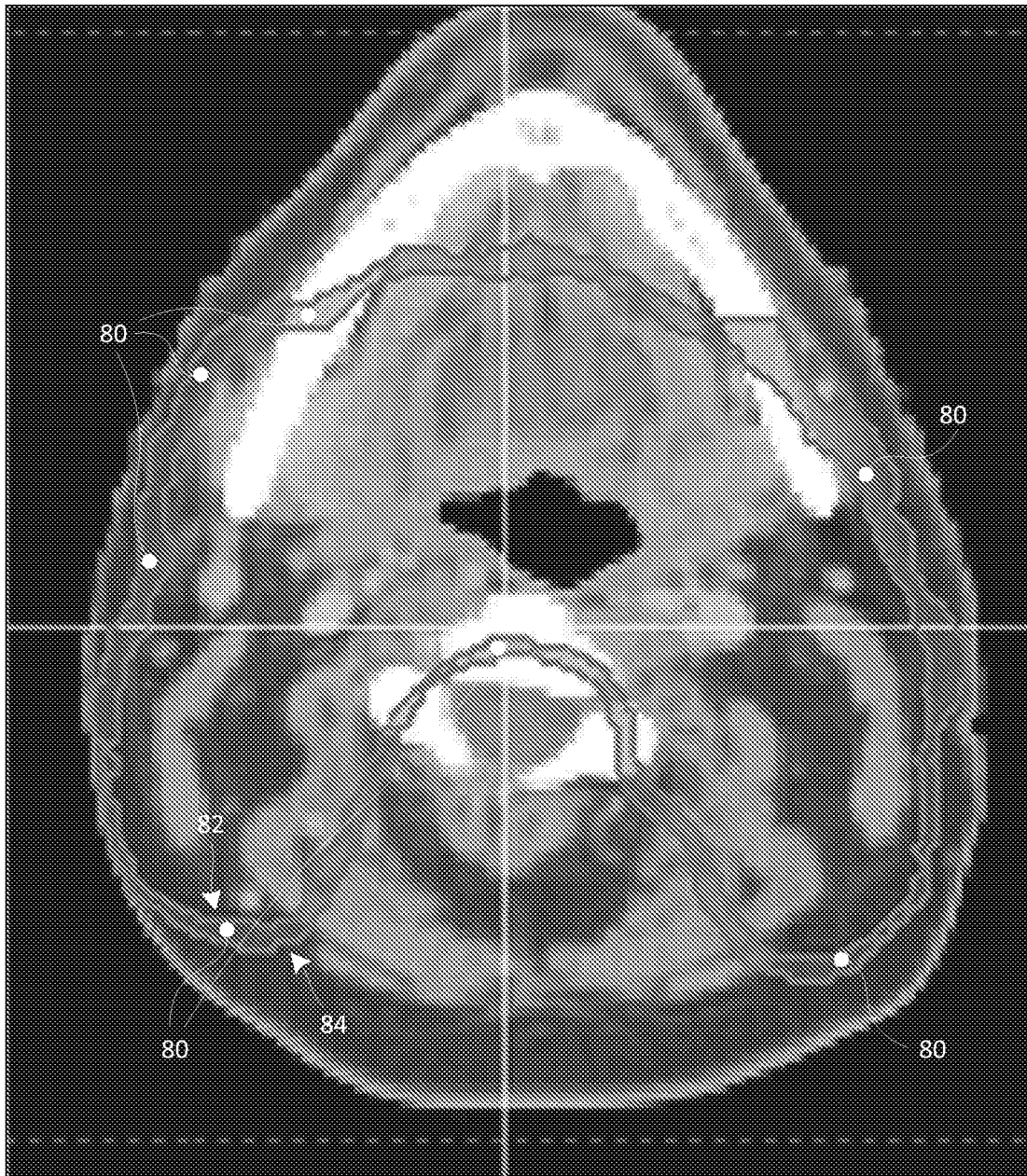
FIGURE 1

FIGURE 2
PRIOR ART

FIGURE 3
PRIOR ART

FIGURE 4

Receive isodose lines, DVHs 90

Define ROIs from isodose lines and DVH 92

Filter ROIs 94

Calculate dose objectives 96

Generate optimized plan based on ROIs and dose objectives 98
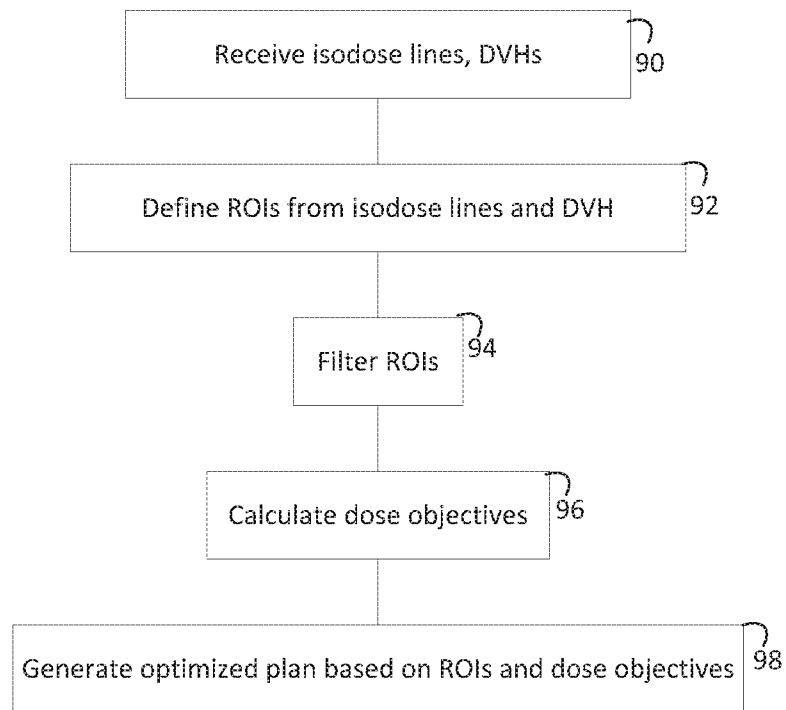
FIGURE 5

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61N5/10
ADD.

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)

A61N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 373 844 A (SMITH VERNON [US] ET AL) 20 December 1994 (1994-12-20)	1,2, 4-12, 14-20
Y	abstract; figures 3A-C column 3, line 65 - column 4, line 1 column 4, line 66 - column 5, line 6 column 5, line 54 - line 63 column 11, line 44 - line 59 column 12, line 17 - line 45 column 13, line 25 - line 28 ----- -/--	3,13

[X] Further documents are listed in the continuation of Box C.

[X] 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

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Date of the actual completion of the international search	Date of mailing of the international search report
16 June 2014	26/06/2014

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Kajzar, Anna

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PHOTON TREATMENT PLANNING COLLABORATIVE WORKING GROUP ED - PODGORSAK E B: "Three-dimensional display in planning radiation therapy: A clinical perspective", INTERNATIONAL JOURNAL OF RADIATION: ONCOLOGY BIOLOGY PHYSICS; [PUBLICATION // DIVISION OF SCIENTIFIC AND TECHNICAL INFORMATION, INTERNATIONAL ATOMIC ENERGY AGENCY, ISSN 0074-1876 ; 1196], PERGAMON PRESS, USA, vol. 21, no. 1, 15 May 1991 (1991-05-15), pages 79-89, XP026844471, ISSN: 0360-3016 [retrieved on 1991-05-15] abstract -----	3,13
A	WO 2013/024534 A1 (MITSUBISHI ELECTRIC CORP [JP]; FUJI HIDEKI [JP]; TAKATANI YASUYUKI [JP) 21 February 2013 (2013-02-21) abstract; figures 4-7 -----	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

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US 5373844	A	20-12-1994	NONE		
WO 2013024534	A1	21-02-2013	CN	103702716 A	02-04-2014
			EP	2745874 A1	25-06-2014
			TW	201309267 A	01-03-2013
			US	2014094642 A1	03-04-2014
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