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Оглавление | Content

Цифровая Земля: от идей к воссозданию виртуальной копии планеты

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Аннотация

Рассматриваются концептуальные основы Цифровой Земли в контексте социально-техногенного развития мира, перевода разнообразных социальных и природных процессов в виртуальное пространство с целью последующего моделирования сценариев безопасного устойчивого развития.

Ключевые слова

Инфо-техносфера, Цифровая Земля, виртуальная реальность, биосфера, устойчивое развитие, социотехноприродные процессы.

1. Digital Earth: from ideas to recreating a virtual replica of the planet

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Abstract

The article considers the conceptual foundations of the Digital Earth in the context of the socio-technogenic development of the world, the transfer of various social and natural processes to the virtual space for the purpose of subsequent modeling of scenarios of safe sustainable development.

Keywords

Info-technosphere, Digital Earth, virtual reality, biosphere, sustainable development, socio-technogenic processes.

Введение

В конце 2020 года в России в дистанционном формате прошел Восьмой Саммит Цифровой Земли, объединивший исследователей из разных частей света, вовлечённых в создание виртуальной копии планеты. На Саммите были подведены итоги развития концепции Цифровой Земли во втором десятилетии XXI века (программа Digital Earth Vision 2020), обсуждались вопросы перевода в цифровое пространство социальных и природных объектов и явлений реального биофизического мира. Сам проект «Цифровая Земля» был провозглашен ученым и вице-президентом США Альбертом Гором в последнем десятилетии прошлого века как задача, требующая комплексного междисциплинарного решения на платформе информационных технологий (Gore, 1998). К решению этой ключевой задачи XXI века должны быть привлечены специалисты из разных дисциплин и из разных стран. Цифровая Земля, как многомерная информ-система, призвана в перспективе обеспечить сотрудничество международного сообщества в решении глобальных и локальных задач

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современного развития. В 2005 году высокотехнологичная транснациональная корпорация Google представила новые массовые сервисы Google Earth и Google Maps, продемонстрировавшие всему миру возможности проекта.

Первые инновационные решения класса Цифровая Земля в России были представлены Всероссийским научно-исследовательским институтом электромеханики в проекте «Неоглобус», в его основе – идея формирования постоянно обновляемой геопространственной информации о поверхности всей планеты в виде динамичных космических изображений (2009). Почти десятилетие спустя, в 2017 году Правительство России официально дало старт проекту «Цифровая Земля» в нашей стране, его основным исполнителем назначена государственная корпорация «Роскосмос». Лучшим российским продуктом, созданным в концепции Цифровой Земли, на настоящий момент является геоинформационная система «Спутник» компании «Геоскан», предоставляющая возможности визуальной репрезентации и анализа разнокачественных геопространственных данных. В Российской Федерации складывается достаточно обширная сеть взаимосвязанных центров, вовлеченных в процессы воссоздания цифровой копии планеты. К ним относятся исследовательские центры вузов и научных организаций, расположенные в Москве и Московской области (Протвино), Санкт-Петербурге, Перми, Брянске, проводятся научные мероприятия в Новосибирске, Томске, Иркутске, Петропавловске-Камчатском и Южно-Сахалинске. Ведущими отечественными учеными осознается острейшая необходимость коренных перемен в стратегическом научно-техническом развитии страны в контексте создания прорывных инноваций (Онищенко и др., 2020). На наш взгляд, такими инновационными разработками, формирующими в будущем возможности моделирования разнородных сценариев социально-экономического, технологического и биосферного развития, могли бы стать технологии Цифровой Земли (Дергачева, 2020).

В различных сферах социокультурной жизни сейчас складываются представления о Цифровой Земле, среди них – новое технологическое направление в искусстве, ориентированное на новое осмысление развивающейся виртуальной реальности жизни (Digital Earth, 2020). В планетарном масштабе, как показали итоги Саммита 2020 года, проектные научно-исследовательские центры и связанные с ними общественные организации охватывают все континенты Земли за исключением Антарктиды. Среди ключевых рассматривавшихся на Саммите Цифровой Земли проблем – вопросы дистанционного зондирования, цифровизации социально-экономических, природных, образовательных процессов, перспективы устойчивого развития, противоречия становления новой этики цифрового мира.

Стоит особо подчеркнуть, что несмотря на определенные достижения в реализации проекта, виртуальная копия планеты еще не создана, этот проект еще только в самом начале пути. Как предполагается создателями проекта из разных стран, Цифровая Земля – это стратегическая система будущего, концентрирующая постоянно обновляемые системные данные о биофизических объектах земной среды и предоставляющая инструментарий к управлению устойчивым коэволюционным развитием общества и трансформируемой им природы. Возможно, если проект будет представлен в завершенном виде, то есть воссоздан в деталях целостный образ земного мира, это позволит мировому сообществу осуществлять геоинжиниринг планетарных процессов, поскольку социоприродный мир сейчас опасно меняется из-за стихийного внедрения достижений научно-технической революции. Еще не воплощенные в жизнь идеи о возможном управлении биосферой Земли высказывает мировая экономическая и политическая элита – представители ежегодного Всемирного экономического форума в Давосе (Шваб, 2019). Тем не менее, вне внимания данного проекта оказывается более важный и перспективный проект – «Живая планета», поскольку воссоздание его в виртуальном мире требует гигантских инвестиций.

Предтечей обсуждений цифровой визуализации планеты следует считать художественные произведения М.А. Булгакова «Мастер и Маргарита» (1928-2940) и Л.Н. Толстого «Война и мир» (1869) (Булгаков, 1926-1940). В них впервые были рассмотрены «живые» глобусы с фантастическими для той эпохи возможностями изучения земных объектов в динамике. Эти предвосхищающие время глобусы предполагали всемасштабное, всеракурсное и беззнаковое представление обстановки. Фактически форсайт Цифровой Земли в России начался за полтора столетия до знаменитого выступления А. Гора о необходимости разработки качественно иной системы презентации геопространственной информации (Digital Earth, 2019). Необходимость появления Цифровой Земли ощущалась в разных культурах – например, в работах известного архитектора и визионера Р.Б. Фуллера (1928) (Jackson, 2018).

Профессором Э.С. Демиденко в 1995 году был предложен проект «Всемирная Информ-Энциклопедия» мультимедийного содержания, поддержанный в Декларации ООН, Международной Академии информатизации, Администраций Московской области и Дубны, предусматривающий качественные оценки порегионально всех объектов и процессов развития мира на основе систем сертификации по качеству и экологии. Его звено уже отрабатывается в Калининградской области, и это может найти место в разработках обсуждаемого проекта (Demidenko, 1995).

В технических науках «живой» глобус Цифровой Земли отождествляют с динамической системой представления геоинформационных данных вне привязки к масштабам традиционных карт. В отличие от узкой технической интерпретации развиваемое нами в этой и других работах понятие «Живая Земля» объединяет разнообразные явления естественной биологической жизни, взращенной миллионами лет эволюции биосферы, включая и самого человека как биосоциального организма (Демиденко, Дергачева, 2020). В данной статье речь идет о наполнении виртуального пространства цифровой планеты не просто геоинформационными данными. Имеется ввиду расширенная модель воссоздания в виртуальном пространстве биосферы во взаимосвязи социальных, природных и воздействующих на современное эволюционное развитие техногенных процессов. Неотъемлемым элементом этих процессов является человек, визуализация которого в динамической искусственной среде виртуальной планеты представляется необходимой. Ведь если в виртуальном «глобусе Воланда» из романа М. Булгакова «Мастер и Маргарита» есть люди (Булгаков, с.268), то для того, чтобы воспроизвести реальную Землю в цифровом пространстве, необходимо представить в историческом ракурсе эволюционные изменения, происходящие с человеком. Визуализация глобальных социально-техногенных изменений в биосфере и человеке представляет собой цифровой вызов информационным технологиям, воссоздание в деталях процессов Живой планеты – биосферной системы жизни в единстве общества, человека и природы. Для воплощения этой идеи в цифровом пространстве необходим междисциплинарный симбиоз информационных технологий с естественными и социально-гуманитарными науками. Возможно, мы уже ведем речь о конструировании «машины времени», поскольку проект «Цифровая Земля» позволит в динамичных картинках моделировать ретроспективные и перспективные процессы.

В реализуемом проекте силами различных международных исследовательских групп речь идет о комплексном моделировании Земли, включая социальные и культурные объекты (Digital Earth, 2019). Цифровая Земля – это «визуальный феномен», то есть, геоинформационная система, построенная на многомерных высококачественных визуальных изображениях. В отличие от имеющихся карт Цифровая Земля (или в терминологии российских исследователей – «неогеография» (Еремченко, 2019)) обеспечивает возможность интерактивного, внемасштабного, всеракурсного просмотра разнородных объектов, включая и корректировки дистанций просмотра изображений (Еремченко и др., 2018).

Разнообразие мнений и исследовательских позиций свидетельствует о том, что концепция Цифровой Земли только формируется. Как надеются разработчики проекта «Цифровая Земля» из разных стран, в этой виртуальной среде должен найти наиболее полное отражение образ реального мира как социального, так и природного (Digital Earth, 2019). Поскольку современный мир развивается по социально-техногенной модели, то визуализация разнородной информации в Цифровой Земле обусловливает необходимость системного представления социально-экономических, искусственных и природно-биологических процессов в их взаимосвязи для воспроизведения виртуального «двойника» планеты.

Методология

В качестве ключевой методологии в наших исследованиях выбираются два подхода – социоприродный и междисциплинарный. Первый восходит к исследованиям В.И. Вернадского первой половины XX века о биосфере и ноосфере и учитывает взаимосвязь социальных и природных явлений (Вернадский, 2001). Второй набирает силу сейчас, в XXI веке, поскольку все больше наук осознают необходимость системного взаимодействия с целью расширенного понимания происходящих в обществе и природе изменений. Центральным звеном в междисциплинарном подходе является теория философии социально-техногенного развития мира, социотехноприродных процессов и смены эволюции жизни, истоки этой концепции – в работах профессора Э.С. Демиденко, основателя авторской научно-философской школы, его учеников и последователей (Демиденко и др., 2011; Философия социоприродного взаимодействия, 2018). Опора на эту теорию позволяет учитывать при разработке образа Цифровой Земли и моделировании ее процессов сложные системные взаимодействия в техногенном обществе, его экономике и естественной природе на основе развития искусственного мира и его разнообразных биотехнологических форм жизни и подавления ими биосферы как единого целого самой жизни. Развивающийся на научно-технологической основе частной собственности капиталистический организм воздействует на биосферную природу (включая и человека) не столько изменяя ее положительно, сколько негативно трансформируя и уничтожая ее. Визуализация изменений в биосфере и человеке важна для целей ретроспективного и перспективного анализа состояния Земли. Виртуальный образ Земли создается на основе инструментария технических наук, но упускается существующий образ губительно изменяющейся живой планетарной системы.

Результаты и обсуждение

Цифровая Земля – это своеобразный виртуальный образ-глобус гетерогенных социально-экономических, экогеографических и иных данных, объединенных с соответствующими алгоритмами их анализа и моделями. Механизм постоянно обновляемых данных в высокопроизводительной вычислительной среде позволяет увидеть состояние систем Земли (атмосферы, гидросферы, литосферы) в их исторической динамике, провести мониторинг изменений, построить вероятный прогноз на будущее. Данный проект носит междисциплинарный характер, поскольку, с одной стороны, «на входе» наполняется данными наблюдений разных наук и связан сетью данных цифровых библиотек. С другой стороны, «на выходе» системная аналитика, представленная визуальными моделями, легче воспринимается учеными из разных исследовательских областей. Технологии визуализации данных дают наглядное представление о происходящих в мире социальных и природных процессах. Этот подход формально позволяет совместно применять полученные сведения в естественных, социальных и технических науках, принимать научно обоснованные решения, а в будущем – усилить контроль за состоянием подсистем биосферы Земли. Все это подтверждает тот факт, что Цифровая Земля устанавливает связь между двумя мирами: 1) социальным, биосферным, естественно-неживым, и 2) искусственным, создаваемым социумом с использованием ряда важнейших наук, но, на наш взгляд, далеко не научным, поскольку игнорирует фундамент научного знания – философию, сводя ее к мировоззренческой дисциплине.

В вышедшем в конце 2019 года руководстве по Цифровой Земле, весьма полно отражающем научно-исследовательские разработки, связанные с этой тематикой, человек представлен в аспекте изучения социально-поведенческой активности в виртуальном пространстве. Именно на этом аспекте его жизнедеятельности, связанном с активностью и интересами многих пользователей в социальных сетях, необходимо, как считает ряд исследователей, сосредоточить внимание при построении образа человека в цифровом пространстве. Визуализация поведенческих моделей пользователей сетей (оставляющих «цифровые следы») позволит не только выстроить стратегии маркетинга и дать экономическое обоснование планируемым в виртуальной среде мероприятиям, но и спрогнозировать и даже предупредить социальные катаклизмы, осмыслить взаимосвязи окружающей среды и поведения индивида. Ведь человек на своих страницах в социальных сетях в знаковой форме делится чувствами и эмоциями о событиях из реального мира (Digital Earth, 2019). Поэтому изучение психологических аспектов и построение отвечающего им меняющегося социокультурного облика человека вполне оправдано с точки зрения перспективного безопасного развития социально-техногенного мира, в котором биосфера будет существовать как саморазвивающаяся система.

Вследствие стихийного социально-техногенного развития мира эволюционно меняется во многом стихийно и сам человек разумный как биосоциальное существо, жизнедеятельность которого связана преимущественно далее с разрастающейся техно-урбанистической средой жизни. Естественный человек, взращенный миллионами лет эволюции биосферы, в техносферной оболочке жизни подвергается трансформациям в трех сферах – социокультурной, природно-биологической и искусственно-техногенной. Визуализация взаимосвязанных эволюционных социотехноприродных изменений в человеке представляет несомненный интерес для проекта «Цифровая Земля» как с точки зрения изучения антропогенеза в научных и образовательных целях, так и с позиций разработки перспективных программ сохранения его биосферного тела и природного здоровья в динамично развивающемся социально-техногенном мире.

Общество, состоящее из людей, является подсистемой биосферы, эволюционирующей на протяжении многих тысячелетий в биосферной системе жизни. Около трех столетий назад при переходе к индустриально-техногенному развитию в условиях промышленной революции (XVIII в.) роль доминанты во взаимоотношениях «социум-природа» начинает переходить к техногенному обществу, которое уже существенно перестраивает естественную природную среду жизни, создавая вместе с ней биотехнологическую экономику – индустриальную и постиндустриальную (Дергачева, 2020). Промышленная революция (XVIII в.) создает условия для коренного перехода общества к массовому социально-техногенному развитию биосферы и машинно-техническому подчинению в XIX – XXI веках природы техногенным социумом, что приводит к массовому уничтожению биосферы. Достаточно отметить, что с 1970-х годов научный мир фиксирует катастрофические темпы снижения на две трети биоразнообразия планеты (WWF, 2020), то есть утрату естественных технологий воспроизводства биологической жизни.

Техногенно развивающееся общество на основе разнообразных индустриальных технологий создает искусственную предметно-орудийную, вещественную и электромагнитную среду жизни – техносферу, техногенно трансформирует биосферу, ее природно-биологические процессы и организмы. В городской техносфере в третьем десятилетии XXI века проживает около 4 млрд человек – более половины населения земного шара, тогда как в 1800 г. всего лишь около 50 млн человек. Биотехнологическая экономика, сосредоточенная преимущественно в городской среде, направлена на расширенное воспроизводство искусственных, биотехнологических, виртуальных и иных техногенных процессов в масштабах планеты. Активно развивается виртуальная цифровая экономика (как разновидность постиндустриальной) в аспекте моделирования региональных (Кулагина и др., 2020) и национальных (Макаров и др., 2017) процессов. Формируется рациональная техносферная система жизни, в которую постепенно социум переводит все процессы биотехнологического воспроизводства жизни (Демиденко, Дергачева, 2020). Переходными «рациональными» формами жизни между естественным и искусственным мирами являются разнообразные клонированные организмы, включая и техногенно изменяемого человека.

Складывается интегрированное взаимовлияние процессов социально-экономического, техносферного и биосферного развития, что приводит в конце концов к экспансии процессов социотехноприродного развития мира (Дергачева, 2016), техногенной трансформации биогеохимических круговоротов веществ, а в более общем плане – смене направленности эволюции – от биосферной к постбиосферной, во многом искусственной (Демиденко, Дергачева, 2020). Эти и другие вопросы постбиосферного биотехнологического развития жизни в городской техносфере и формирования постбиосферного человечества поставлены в центр внимания ученых и исследователей российской Междисциплинарной научно-философской школы социально-техногенного развития мира, социотехноприродных процессов и смены эволюции жизни, работающей при Брянском государственном техническом университете с 2002 года (Dergachev, Trifankov, 2019; Попкова, 2019).

Нарастание процессов социотехноприродного развития мира свидетельствует о том, что проект «Цифровая Земля» является ценным и логическим отражением глобальной технологизации всех жизненных процессов в биосфере, а далее также своеобразной библиотекой больших данных создаваемой техносферы. В создаваемом техномире следует различать две его составляющих – постбиосферный мир (физически осязаемый, техносферный) и внебиосферный (виртуальный, дополненный воображением людей, знаковый, описанный техническими средствами информационных технологий). Виртуальный инструментарий (информационные технологии) – это уже инфо-техносфера (Лапченко, 2009), обеспечивающая функционирование техносферной оболочки жизни.

На поддержание же работоспособности нематериального, виртуального пространства расходуется существенно нарастающее количество электроэнергии биофизического мира. Техносфера, соединяясь с техногенно развивающимся обществом и техногенно трансформируемыми ими регионами биосферы, формирует уже полуискусственную (т.е. переходную к искусственной) социотехноприродную систему жизни.

Заключение

Главная задача современного социума – сберечь необходимую для жизни человека биосферу в условиях стихийно нарастающего социально-техногенного развития мира. Рассмотренные в статье во многом стихийные социально-техногенные трансформации, необходимо включить в содержание виртуальной среды Цифровой Земли. Системное представление эволюционно изменяющейся биосферы в расширяющейся искусственной среде важно с точки зрения разработки всех перспективных программ устойчивого развития в трансформирующемся и порочно развивающемся социально-техногенном мире. Эффективное принятие решений по поддержанию жизнеспособности биосферы напрямую зависит от качества восприятия контекста, в котором эти решения принимаются. Контекстом в данном случае выступает геопространство цифровой Земли.

Качество управления виртуальным геопространством определяется качеством моделирования в нем социальных, техногенных и природных процессов. До последнего времени анализ геопространства велся преимущественно на основе данных, представленных в традиционных картах и геоинформационных системах. Информационные технологии Цифровой Земли представляют более совершенный инструмент, поскольку они избегают статичности изображения мира, позволяют видеть мир таким, каким он есть в реальности. С помощью инструментов научной визуализации мы получаем возможность видеть "Живую Землю" (биосферу) натуральным, "живым" образом без использования "мёртвых" опосредующих условностей (знаков, моделей, категорий) и планировать программы безопасного социально-техногенного развития мира и человека. Живой мир будет встроен в процедуру принятия решений по управлению социально-техногенными изменениями благодаря имманентному качеству виртуального пространства – натуральности воспроизведения процессов, моделируемых с помощью Цифровой Земли.

Современный мир лишь делает первые шаги в научной визуализации облика биосферы в цифровой Земле. Масштабные задачи для информационных технологий по репрезентации реального образа биосферы в искусственной среде еще предстоит решить. Эти задачи реализуемы только при подключении всего междисциплинарного потенциала естественных, социально-гуманитарных и технических наук.

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Auto-Audit of Digital Earth and Beyond

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Abstract

The question is posed: "If we use the Digital Earth to verify the results of an audit (e.g. land cadastre) conducted in a traditional format, who can verify the Digital Earth itself?" The answer is, "The Digital Earth can audit itself. Only you have to teach it to do it". The mechanism of self-checking is proposed to be realized through autoreflexion. If Digital Earth is "taught" autoreflexion, there are no obstacles to the transition to peer-to-peer reflexion and multirange reflexion. The reflexive model of the Digital Earth is discussed both in the case of ordinary introspection (auto-audit) and in the case of multiple ranks of reflexion. The way of inclusion of the person in the digital network as a support structure of the Digital Earth is discussed. At the next level of development the reflexive Digital Earth becomes recursive, which means development toward the noosphere as understood by academician Vladimir I. Vernadsky – the thinking Digital Earth. Finally, at the highest stage of development Digital Earth will understand man and humanity.

Keywords

Digital Earth, Auto-Audit, reflexion, noosphere.

Introduction

Let me to start with a quote from a philosopher. Josiah Royce in his book "The World and the Individual" formulated the following: "Let's imagine that a part of the land of England has perfectly aligned, and on it the cartographer circles the map of England. The work is perfect; there are no details about the land of England, even if they are minute, that are not marked on the map; everything has its correspondence there. This map in such a case must contain a map of the map, which must contain a map of the map of the map, and so on ad infinitum ."[1] This is nothing more than introspection or self-reflexion: the country looks into itself through its precise map.

Let's extend the thought experiment. A Professor at “Sylvie and Bruno” by Lewis Carroll talked about creating a 1:1 scale map of the country.[2]

Al Gore replaced the map with a globe and came up with a Digital Earth.[3]

Digital Earth is a set of objects digitized and presented in accordance with the principles of neogeography.

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1 Royce J (1900) *The World and the Individual*. First Series. “The Four Historical Conceptions of Being”. New York: Macmillan, p.505.

2 Carroll L *Sylvie and Bruno*. – In: The Complete Illustrated Lewis Carroll. Wordsworth Editions Ltd. Cumberland House, Hertfordshire, 1996. p.556.

3 Gore A (1992) *Earth in the balance: ecology and the human spirit*. Houghton Mifflin Harcourt Publishing, Boston.

Discussion

So we moved from cartography to neogeography, including Digital Earth, which is exactly what we are looking for. Let's continue our thought experiment and imagine a similar process not on the map, but on the whole Earth, on the Digital Earth. Any digital fragment contains the same fragment at a different scale, which in turn contains a fragment at a different scale. This is a mechanism for implementing the scale-independed nature of the Digital Earth.

What are the next steps in the development of the Digital Earth? It seems to me, that we should strive for a Reflexive Digital Earth, that is, a Digital Earth that learn about itself.

This stage requires several steps.

Firstly, for this purpose it is necessary to include the reflexive Digital Earth in the topology of the world wide web. The Internet space is not only a complex technical object, but also a community of persons who enter into various connections with each other and various relationships about the information circulating in the world's infrastructure. Therefore, we must include human beings in the Digital Earth. How do we do this? How is the technical network of the Internet connected to the community (network) of persons where, in fact, a large part of life on Digital Earth unfolds?

So, there is an Internet space as a complex technical object, as a network of technical devices. At each node of the technical network a person appears (or can appear). This means that we can talk about a kind of social network, or rather a set of realizations of a common social network, corresponding to the technical structure of the Internet. Nodes are human inner worlds, but the meaning of the Internet is hidden not in the nodes, but in the connections between them, that is, in the relations between the members of the emerged community. Through the established connections, new content is induced in other nodes of the network. In fact, over the technical part of the network defined by physical connections and connection points (nodes), a second - field (induced) network of connections emerges, describing the circulation of ideas, discussions, finally, public opinion, which defines the community. But how do these two networks create unity? As long as the technical network (the Internet) is not induced (not excited by human informational influence), it is only a physical circuit. The induced network is the human essence of the Internet. Thus, nodes are connected not only by physical connections, but also by "force lines" of the induced field. And once the relationship between the "nodes" has arisen, it requires social regulation. In this sense, Digital Earth, as a space "stretched" on the Internet becomes not only a technical, but also a social phenomenon. The technical Internet network induces a social network of thinking elements of the Digital Earth.

So, the Internet as a support structure of the Digital Earth is a dual system, the physical subsystem of which is a set of loops and node pairs. Analysis of the physical subsystem of the Internet, for example, in order to establish the optimal routing is done by methods of graph theory. Mathematically, we can incorporate the social network into the Digital Earth through a graph theory model, translating the graph of the technical network into the graph of representations that each of its elements has. Analysis of the field (induced) subsystem of the Internet, which describes the circulation of information and collective generation of content, as much more complex, requires the use of tensor analysis. The field subsystem can be described by equations like Ohm's law and Kirchhoff's law for electric circuits or by thermodynamic analogies, for example by introducing information potentials. It is possible to look at the Digital Earth in a different way, through a complex structure of configuration Internet space, its stratifications (Tor Browser, Dark Net), through deep floors of the Internet space - different kinds of online universes (worlds), etc. But that's another topic.

About 10 years ago, at the Institute for the history of natural science and technology of the Russian Academy of Sciences, we implemented a digital globe where we demonstrated 3D-documents with a coordinate reference and Internet connection to get real-time information.[4] (The concept 3D-document was introduced by Diter Fellner in 2007.[5] It has proved extremely useful for the Digital Earth). We transferred this technology to the Geophysical center of the Russian Academy of Sciences, where they successfully developed it.

Lets go to the next steps.

Each of us has self-awareness. But to understand who we are, what humanity is, we as a community must have self-awareness. This procedure – self-discovery (auto-audit) of humanity, that is, the interpretation of many random external signals that tell us who we are, can be carried out by starting from the Digital Earth. In addition to introspection, this will also allow us to interpret reality.

If we use the Digital Earth to check the results of an audit (e.g., a land cadastre) conducted in a traditional format, who can check the Digital Earth itself? The answer is simple: the Digital Earth

[4] Baturin YuM *Modelling As a Backup Tool for the History of Science and Technology*. – Herald of the Russian Academy of Sciences, 2013, vol.83, No.1, pp.1-7.

[5] Fellner DW, Saupe D, Krottmaier H *Guest Editors' Introduction: 3D Documents*. IEEE Computer Graphics and Applications, vol. 27, no. 4, July-Aug. 2007, pp. 20-21.

can check itself. But we have to teach it to do this. An attempt can be made to implement the self-test mechanism through autoreflexion. In fact, it is necessary to introduce a feedback mechanism, a kind of "mirror" by means of which the Digital Earth, as a global phenomenon, can check and, therefore, correct itself (auto-audit).

If Digital Earth is "taught" autoreflexion, there are no obstacles to the transition to peer-to-peer reflexion and multirange reflexion, which means that it becomes a potential interlocutor. Hypothetically such an interlocutor could be an extraterrestrial mind, but we will not discuss this version as irrelevant for now.

So, we got a Reflexive Digital Earth. In other words, Digital Earth will contain a model of the Digital Earth, with which it interacts, realizing itself, talking to itself. It will already be a reflexive Digital Earth.

What's next? We can set the task of increasing the ranks of reflection. That is, create a recursive Digital Earth. And this means moving towards the emergence of the noosphere, as it was understood by academician Vladimir I. Vernadsky.

Finally, the next step is to move away from the traditional coordinate systems used in cartography and GIS to p-adic coordinate systems as more appropriate to human thinking.[6] With the appearance of Descartes' coordinate system, a numerical image of physical space was actually created. However, a lot of efforts and time were still needed to create an accurate mathematical model to digitize physical space. It was necessary to create a mathematical structure in which the process of reducing the size of the Cartesian lattice could go on to infinity, guaranteeing in the limit the infinite accuracy of the digital representation of material objects. The corresponding mathematical structure is now known as the field of real numbers. But to describe the mind, the thinking Digital Earth will need to move from real numbers and traditional digitization to p-adic numbers and corresponding tree-like coordinate system, which entails a fundamentally different digitization (another very specific way of information coding). It is necessary to move from traditional digitization to coding based on p-adic numbers. It is in this direction that we see a real way to model human thinking and create artificial intelligence. A "re-digitized" and therefore altered Digital Earth will be able to understand humans and humanity. Perhaps this will be the Earth with a noosphere according to academician Vernadsky, at least one of its interpretations.

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[6] Khrennikov A.Yu. *p-adic information spaces, infinitely small probabilities and anomalous phenomena.* – Journal of Scientific Exploration, 1999, vol.4, # 13, p.665-680.

Conclusions

Thus, we will gradually get:

- a reflecting, self-aware Digital Earth (auto-audit of Digital Earth)
- a Digital Earth with an increasingly high rank of reflection (this is the path to the noosphere)
- a Digital Earth that understands a person and humankind.

Digital Earth must become the interlocutor of humanity. This task is practically essential to the survival and preservation of humans as an Earth species.

Digital Earth is rapidly evolving, as is its configuration space, the "receptacle" of this phenomenon itself, a well-visualized network (many are familiar with picture-charts of this kind) stretched over many reference points located all over the planet and even in near-Earth (so far) outer space. Humanity cautiously enters new nooks of Digital Earth that are opening up and starts mastering them. But the new subspaces of the Digital Earth pose many practical questions for scientists, which are not easy to solve. But they at least need to be formulated and posed.

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The Features of Legal Regulation of Big Data in the Context of the Development of the Digital Earth

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Abstract

When creating a Digital Earth, huge amounts of data are generated through remote sensing and various sensors to observe our planet. Big Data has become of particular value in the context of the development of the Digital Earth. At the same time, every day there is more and more information, which creates serious problems for their collection, storage, processing, ensuring their security and legal regulation. The advent of cloud technologies has made it possible to provide computing support for collecting, storing and processing Big Data, while the heterogeneity of the amount of data collected is growing and it becomes difficult to determine their legal regime, jurisdiction and protection in general. The report analyzes the sources of Big Data used for the development of the Digital Earth, the peculiarities of their collection, storage and processing through cloud technologies, analyzes the prospects and risks of the development of the Digital Earth in terms of the security of Big Data and their legal regulation.

Keywords

Digital Earth, Big Data, Cloud Technologies, Legal Regulation, Information Security, IT.

Introduction

The rapid development of the digital economy every day leads to an increase in the amount of data, its heterogeneity and unstructuredness. In this connection, the term Big Data appeared in popular science terminology, which is attributed to almost any data collected from a variety of sources. In the Strategy for the development of the information society of the Russian Federation for 2017-2030[7], it is noted that the processing of Big Data is one of the most important issues in the context of the development of information technologies. To collect, process, store such data, cloud technologies are used, which are also among the priorities in terms of the development of the digital economy and the Digital Earth.

It should be noted that the term Big Data, as well as its definition, is not legally enshrined either in Russian legislation or in other foreign laws. In the Russian law on personal data, there are concepts such as personal data, biometric personal data. The GDPR law includes similar concepts, as well as genetic data, data related to health. In the United States, there is no federal regulation of the term Big Data. Despite the status of the most advanced states in the world in terms of digital technologies, the United States does not have a single centralized approach to regulating the protection of personal data and, moreover, Big Data. The rules governing the legal procedure for the

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[7] Decree of the President of the Russian Federation of 05.09.2017 № 203 «On the Strategy for the Development of the Information Society in the Russian Federation for 2017 – 2030»

use of such data are scattered across many acts, for instance:

- The Fair Credit Reporting Act (15 U.S.C. §1681);
- The Health Insurance Portability and Accountability Act (HIPAA) (42 U.S.C. §1301);
- The Financial Services Modernization Act (15 U.S.C. §§6801-6827);
- The Electronic Communications Privacy Act (18 U.S.C. §2510);
- The Computer Fraud and Abuse Act (18 U.S.C. §1030).

The difficulty of defining the term Big Data is understandable. After all, data collection is carried out from a variety of sources. These include remote sensing of the Earth, geotechnology, face recognition technology, the IoT, mobile phones and other electronic devices, the Internet, distributed registry technologies. Entertainment content and video surveillance have long been important sources of growth in the global data space. As we move digital, there is a growing share of data from IoT devices, metadata (critical for analytics, contextualization, and artificial intelligence), and operational data. Four industries have the greatest potential for data generation: healthcare, industry, financial sector, and media business. In addition, Big Data is structured and unstructured information from a large number of different, including scattered or loosely coupled, sources in volumes that cannot be processed manually in a reasonable time. According to the representatives of the expert community, structured data is understood as ordered information contained in databases, information systems, etc. And unstructured data is information contained in audio and video recordings, text included in graphic images, that is, data in formats making it difficult to find specific information in them.

Discussion

According to a late 2018 study by IDC, the global data sphere will more than fivefold by 2025, to 175 ZB, up from 33 ZB in 2018[8]. At the same time, the volume of the global data sphere is determined by the volume of new data created and reproduced per year. Storage is also expected to undergo significant changes. The share of data stored in public clouds is increasing, and by 2025 this share will reach 45-50%[9]. This leads to the complication of centralized collection, storage and manual processing of data. Moreover, cloud technologies are directly related to the Internet, and here comes the jurisdictional aspect of storing data about citizens of different states and the issue of

8 [Electronic resource] URL: https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf

9 [Electronic resource] URL: http://www.garant.ru/article/1263975/

responsibility for the confidentiality and security of this data. Cloud technologies are used to store certain data in absolutely all areas, and as noted earlier, the development of cloud technologies is a priority among the tasks in the development of the digital economy and the creation of the most accurate picture of the Digital Earth.

The increasing availability of Big Earth data has provided unprecedented opportunities to understand the Earth in the Digital Earth context. In recent research, Big Data have been characterized by 5 Vs (volume, variety, velocity, veracity, and value).[10] «Data collection strategies, data storage facilities, data analysis methods, and data access services facilitate the transformation from the other 9Vs to the 10th V of value. With the continuing increases in the volume and complexity of data, there are challenges in the life cycle of data management, including data storage, data query, data analysis, data sharing, and many other aspects. Managing Big Data requires an extensible, interoperable and scalable architecture that supports data storage and analysis. Fortunately, recent years have witnessed the evolution of cloud computing, which brings potential solutions to support the life cycle of big data management».[11]

Together with the term «cloud technologies» in regulatory legal acts, there are such terms as: cloud computing, cloud services, cloud, distributed information systems, service-oriented information systems, service-oriented architecture, software as a service, software rental, applied information systems of the «SaaS» model, cloud computing, consulting in the field of information services and a number of others. Undoubtedly, cloud technologies are gaining more and more popularity and more and more advanced formats for collecting and storing data in the cloud computing environment appear. The essence of cloud technologies boils down to the fact that instead of acquiring and using their own computing equipment, they directly use the computing resources of a company that provides services based on cloud technologies. The advent of cloud technologies has made it possible to provide computing support for collecting, storing and processing Big Data, while the heterogeneity of the amount of data collected is growing and it becomes difficult to determine their legal regime, jurisdiction and protection in general. In this connection, there is a risk of hacking, theft and abuse of the information received. Today there is no single organization that would centrally control and conduct regular audits of available and accumulating data from different sources. Some subordinate bodies have similar powers. For

[10] Marr B (2015) *Big data: using SMART big data, analytics and metrics to make better decisions and improve performance*. John Wiley & Sons, Hoboken, NJ

[11] Yun Li, Manzhu Yu, Mengchao Xu, Jingchao Yang, Dexuan Sha, Qian Liu and Chaowei Yang (2019) *Chapter 19: Big Data and Cloud Computing* In: Annoni A, Goodchild M, Guo H. (eds), Manual of Digital Earth, Springer, pp. 325-357. DOI:10.1007/978-981-32-9915-3_23

example, in November 2020, the Russian Ministry of Internal Affairs announced that it plans to create a centralized bank of biometric data of Russians and foreign citizens by 2023. According to the Ministry of Internal Affairs, the technology will allow identification of a person, as well as unidentified bodies by fingerprint information, facial images and genomic information. The development will interact with the combined search federal system for genetic identification. However, due to the fact that the foundation of any technology is foreign development, then here too one has to face restrictions in the field of full access to the necessary information. That is why in Russia it is planned to switch companies to domestic software development in order to avoid the dependence of Russian companies on foreign software and electronics.

Conclusions

The main problems of legal regulation of Big Data are lack of classification and identification of Big Data and lack of understanding of the limit and boundaries of data collection and establishment of its legal regime. In addition, the concept of Big Data is not defined and legislatively fixed. The problems of cloud technologies are that the subjects of cloud technologies are not defined, the security and privacy of Big Data stored in the cloud is vulnerable and the boundaries of jurisdictions are not defined. Thus, legal regulation of Big Data and cloud technologies must take into account the jurisdictional aspect and data centralization. The prospects for the development of cloud technologies and Big Data are clear. It is obvious that cloud technologies will continue to be used everywhere, new capacities will be developed, centers for collecting, processing and storing information will be created. New software will evolve for high-performance and reliable storage systems, leading to the rapid development of the Digital Earth and the ability to analyze the most complex data and extract conclusions in real time.

It is crucial to identify as accurately as possible both the data and the sources that produce and process it to build an organized Big Data environment. In this case, more precise control and data audit will be possible. To develop the Digital Earth and ensure the confidentiality and security of databases and data themselves, it is necessary to identify and classify data and their sources, introduce into legislation the concepts of Big Data and its definitions, designate the legal regime, conduct regular audits and implement control mechanisms for accessing Big Data. There is the need to transfer of databases and cloud technologies, as well as from subsequent collection, storage and processing to domestic developments, as well. For the objectivity of the collection, processing, storage, audit and control of databases without abuse of one's own powers, there is an urgent need to create an independent organization to protect the confidentiality of Big Data in the era of development of information technology, the digital economy and the Digital Earth.

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Data Management in the Transition to the Digital Economy (2019, March 19) URL: http://www.garant.ru/article/1263975/ Accessed 30 Dec 2020

Automotive Digital Earth: Big Data, Insurance

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Abstract
The article is devoted to the implementation of Big Data technology in the auto industry and insurance. The article substantiates the need to use this technology in the context of rapidly growing volumes of information, describes the role of big data in modern life and predicts its use in the concept of the future development of the Digital Earth. The current level of Big Data usage in the automotive sector in Russia and around the world is considered. The author describes the main areas of application of Big Data, such as car insurance using telematics devices, navigation, improving the production process of cars in terms of identifying and eliminating system flaws that are detected during operation, as well as about the growing popularity and at the same time causing heated controversy of the technology of unmanned driving. Statistical data on the number of self-driving cars in countries, the level of their introduction into everyday life, and people's readiness for a new stage of transport development are presented. Separately, the author raises the question of the legal regulation of Big Data, which at this stage is in its infancy and requires careful study, identifies current legal problems that arise in the process of implementing this technology. As a solution to the problem, a number of measures are proposed to fill the existing gap and establish compliance with the rule of law and common principles for the use and protection of Big data.

Keywords
Big Data, Digital Earth, Self-driving cars.

Introduction

One of the branches of Digital Earth society is the information service technology, as well as possibilities for future development of human life on earth in general. The amount of information in all areas of our life is constantly growing, so we have to develop advanced technologies such as the Internet of things, artificial intelligence, blockchain and Big Data, which create an opportunity to move to an absolutely new level of life on Earth.

The Digital Earth concept implies a future with a free access to knowledge, any scientific or cultural information, which will enable the entire mankind to better understand our planet itself and how it is affected by human activity.

There is a rapid development in the area of the so-called “Big Data” which directly contributes to our everyday life. It allows people to deal with large volumes of information in various fields, for example, geomorphology, meteorology, developing “smart cities” infrastructure, medicine, building construction, transport and many others. Today I would like to talk about how Big Data can be applied in the automotive industry. In the modern world the amount of information is increasing rapidly that’s why we need ways to store, process and analyze data, as well as to manage all these processes.

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Discussion

An example of a promising area, involving Big Data, is the automotive field, which includes various branches:

1. Insurance. Realization of the “Pay-as-you-drive” concept (or PAYD). Telematics is successfully utilized by insurance companies, allowing to substantially decrease the cost of a car insurance certificate. It also simplifies and speeds up the resolution of arguable issues in case of an accident by collecting such data as speed limits, the number of maneuvers, brakings and so forth.

2. Navigation. Cars with a telematics box become a part of the net and form a data current, by sending their coordinates every several seconds. The algorithm forms an efficient way to avoid traffic jams or road works.

3. Information for manufacturers. Big Data is actively used by automobile manufacturers: this includes information about a car’s condition or about any possible trouble that a user can face during exploitation which helps to expose defects or reasons behind failures. Sellers also exploit such information with planning the purchase of spare parts or possible repair works.

4. Self-driving cars. As this area is attracting more and more attention, the amount of generated data is increasing as well. Here the main source of information is sensors and navigation system. Later on this will include information about the interaction with other road users and infrastructure components.

In accordance with the SAE J 3016-2018 standard "Classification and systematization, as well as definitions of terms related to driving automation systems for road motor vehicles", there are six levels of vehicle automation (Novotest.ru, 2018):

- Level 0 (no driving automation)
- Level 1 (driver assistance)
- Level 2 (partial driving automation)
- Level 3 (conditional driving automation)
- Level 4 (highly automated driving)
- Level 5 (full driving automation)

The second and third levels involve the use of systems such as cruise control, distance and lane control, and emergency braking. At present most vehicles belong to levels three/four, however some manufacturers offer a realization at the fifth stage (which is the case with Mercedes-Benz, for example). The Table 1 demonstrates a list of self-driving cars as well as their manufacturing countries. Their geographical spread is quite wide (Mentamore.com, 2019).

Table 1. Self-driving cars and their manufacturers

Vehicle model	Manufacturer, country
GM Cruise	General Motors, USA
Daimler Intelligent Drive	Mercedes, Germany
Argo AI	Ford Motors Company, USA
Honda	Honda Motor (Japan) and SenseTime (China)
Yandex	Yandex, Russia
Traffic Jam Pilot	Volkswagen and Audi, Germany

KPMG, a consulting company, regularly examines countries' readiness to use self-driving cars. The key factors are: security, data privacy, digital infrastructure, implications for the transport system, optimization of international travel and transportation.

Russia's position in this rating has remained low for several years (KPMG, 2020):

- 2018 year – 18-th place out of 20;
- 2019 year – 22-th place out of 25;
- 2020 year – 26-th place out of 30.

The following criteria were taken into account:

- laws and governmental policy with regard to self-driving cars;
- the level of consumer acceptance;
- technology and innovation accessibility;
- the extent of the infrastructure required.

In November 2019 the Gartner company estimated the number of self-driving cars which came into existence in 2018 and 2019. 2018 showed 137 129 new automated vehicles, whereas in 2019 this number elevated to 332 932 (Gartner, 2019).

According to analysts' data, this number will still be increasing and by 2023 will have reached 745 705 items (Table 2). The main growth is expected in North America, China and Western Europe and these regions are supposed to introduce unmanned driving rules.

The analysis was performed over all vehicles with autonomous driving equipment, meeting the requirements of automation level 3, which are capable of driving without human involvement.

Table 2. Number of self-driving cars in the world

Use Case	2018	2019	2020	2021	2022	2023
Commercial	2407	7250	10590	16958	26099	37361
Consumer	134722	325682	380072	491664	612486	708344
Total	137129	332932	390662	508622	638585	745705

An opinion poll was taken by the IPSOS company (Kommersant.ru, 2018), and as a result it turned out that the interest to self-driving cars prevails all over the world (Fig. 1). Notably, neither North America nor Germany show any particular interest to autonomous vehicles, and that contradicts Gartner analysts' data expecting the number of self-driving cars to rise following the national policy in these countries. However, on average the situation seems to be quite positive throughout the world: 30% of participants are ready to drive such a car, while only 13% will reject this opportunity.

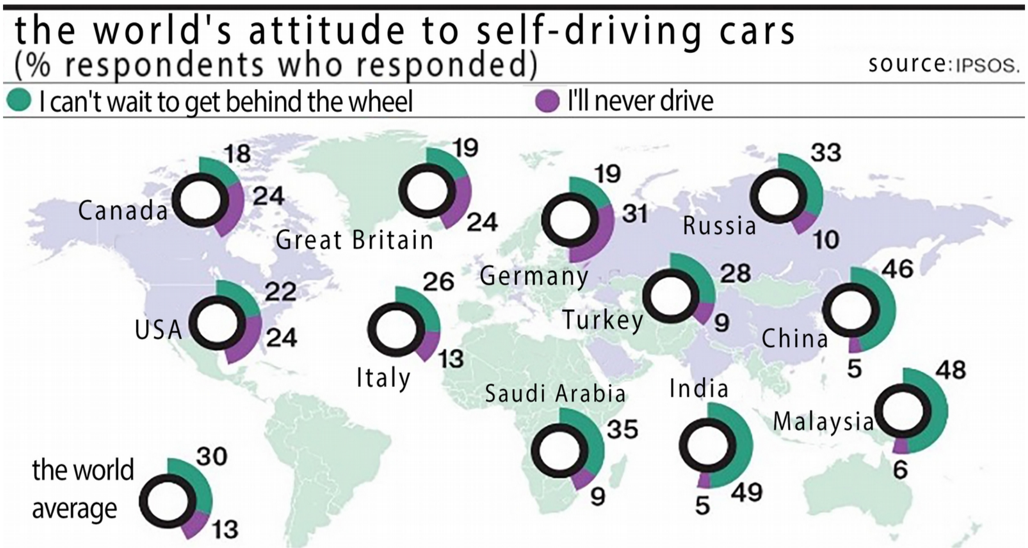

Fig. 1. The results of a survey by IPSOS (Kommersant.ru, 2018)

Regarding the Big Data issue in Russia, it is noteworthy that on the 9th of May in 2017 President signed the Strategy for the development of the information community in the Russian Federation in the period from 2017 to 2030 (Kremlin.ru, 2017). One of the main areas of development, concerning information and communication technologies, is specified as Big Data processing.

Nonetheless, at present in Russia there is no distinct definition for the term “Big Data” despite continuous attempts to introduce one. Several definitions, as well as terminology on the whole, were proposed in draft laws:

- in 2018 by the members of the State Duma (Gov.ru, 2018);
- in 2020 by the Ministry of communications (Gov.ru, 2020).

None of the proposed projects was accepted.

Along with the obvious advantages and development opportunities that Big Data might bring, unfortunately, we should also take into consideration the other side of the coin. Due to the novelty of this technology, there are no procedures for regulating data exploitation and processing. This requires:

- building a comprehensive terminology system;
- defining and demarcating responsibilities among all the participants involved in Big Data handling;
- developing algorithms and systems for Big Data protection and storage.

Conclusions

The use of Big Data technology naturally fits into the Digital Earth concept.

Given the high numbers of drivers throughout the Globe, Big Data management, introduced to the autonomous vehicles sector, is of top relevance to the Digital Earth project.

All in all, the legislative regulation of Big Data is missing, that is why in all ranking lists evaluating a country readiness for self-driving cars, Russia takes the lowest positions.

To sum up, given the international interest to Big Data, I would like to emphasize the necessity to modify our laws and regulations considering the Big Data issues. Besides, it is important to consistently regulate the areas, concerning Big Data and its protection.

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Application of 3D documents in the land cadastre: problems of legal regulation

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Abstract
The article considers the use of 3D documents in electronic document management and land cadastre. Earth audit (cadastre) within the "Digital Earth" is carried out through 3D documents. The technical nature of 3D documents is clear, but the legal regime is quite complex and poorly understood. In this situation, it is impossible to conduct an audit of the Earth through a 3D document without establishing its legal regime. This article identifies possible ways to develop domestic legislation in the field of digitalization on the example of a 3D document and makes suggestions for improving the current legislation and defining the legal regime of a 3D document, including in relation to the land cadastre.

Keywords
3D document, visualization, digitalization, digital economy, electronic document management, digital audit, Earth audit, land cadaster.

Introduction

In the process of transition of the economy of developed countries to the sixth technological stage, the formation of the noonomics, there is an active introduction of information technologies in all spheres of human activity.

The development of visualization technologies and the spread of the Internet have given rise to a completely new type of information landscape that combines not only signs and symbols, but also visual images. Combining different types of information that reflect aspects of external reality in different ways can radically change the perception of the world by persons.

The formation of the economy of mind (noonomics) leads to a wider spread of ways to capture information in the form of a 3D model, and, consequently, the transition to 3D documents.[12]

This new type of document allows you to implement in practice the possibility of all-course, i.e. the most complete and complete, representation of geospatial objects.

Today, a lot of documentation is being converted to digital form: organizational and administrative, accounting and technical. The state cadastre system is also developing and widely applies modern information technologies. It also provides online services.

For example, all Internet users have access to the public cadastral map, a reference and information service designed to provide users with information about the State real estate cadastre on the territory of the Russian Federation. With the help of this system, the user can get reference

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[12] Baturin, YuM, Eremchenko EN, Zakharova MI (2019) *3D-document and Digital Earth*. CEUR Workshop Proceedings. Vol. 2485. pp. 155-158.

information about the full cadastral number, address and area of the land plot entered in the State real estate cadastre without leaving home. The location of land plots is fixed by entering the flat coordinates of their borders in the cadastre. This system allows you to consider the area and configuration of plots, but the terrain is overlooked due to the two-dimensional (plane) of the modern cadastre.[13]

With the development of urban infrastructure, two-dimensional registration of real estate objects is losing its relevance. Modern buildings are primarily characterized by multi-level buildings. Highways, subways, various utilities, residential and administrative buildings can be located at different heights of the same land plot (including above and below ground). Current circumstances require that modern cadastral systems support 3D geometric and topological models and, as a result, use 3D documents in their work.

A 3D model allows you to store the spatial characteristics of an object (geometry, texture, structure, and others) in a three-dimensional coordinate system associated with the object. This property qualitatively distinguishes it from photo and film shooting, which preserve only two-dimensional images of the object.[14]

A 3D document is specially organized information designed to present the user with a three-dimensional (spatial) visual image (3D model) of an object or process, as well as a variety of additional information based on this visual image.

The increasing creation and use of digital 3D models of real objects and processes to save on them resulted in no such thing as a 3D document that is used in the scientific literature for over a decade.

A special feature of the structure and image of a 3D document is that they can be stored as a point or polygon model. For example, as a result of laser scanning, a point cloud is formed, which is a text file in which each line determines the position of one point in space (x, y, z coordinates in a certain coordinate system). When these points are simultaneously displayed on a computer in three-dimensional space, they "contour" the object's surface, allowing the viewer to see a virtual 3D point model of the object.

The geometric accuracy of such a model can reach thousandths of a percent of the object size. However, since it is not able to provide photorealistic visualization and is not convenient for

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analysis, polygonal 3D models are often built on its basis, including textured ones that preserve geometric accuracy with varying degrees of coarsening. The surface of an object in a polygon model is defined by a set of polygons, which are polygons, usually triangles.[15]

Discussion

Using virtual 3D models allows you to capture and save a qualitatively larger amount of information about the spatial characteristics of an object, unlike other methods. This advantage is most pronounced when working with large objects that have a complex geometry and spatial structure. In this regard, the use of digital 3D models is becoming more widely used, especially in the development of scientific and technical documentation.

While remaining an electronic document, a 3D model of an object can be linked by mutual links to other types of object (text, audio, and video files), including on remote servers accessed via the Internet.

From a technical point of view, a 3D document is information organized in a special way that is intended to present the user with a three-dimensional visual image of an object or process, as well as additional information obtained from this visual image.

Considering the format of a 3D document, it should be noted that in addition to the fact that it allows for a much more complete fixation of information about the geometry, structure and appearance of an object, its use allows the user to independently "explore" the object.

This "research" allows you to view the 3D model from different angles, change the display parameters, and study additional information related to the visual image.

3D modeling allows you to accurately reproduce and sometimes recreate objects that have already been lost in order to preserve them for future generations. Domestic developments in the field of 3D documentation of unique objects are conducted at the center for the virtual history of science and technology of the Vavilov Institute of history of natural science and technology of the Russian Academy of Sciences (IHST RAS).

An example of such developments is the project on laser scanning and 3D modeling of the Shukhov tower on Shabolovka, which was carried out as part of the development of the permanent exhibition of achievements of the Russian Academy of Sciences.

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[15] Eremchenko EN, Tikunov VS (2016) *Holographic visualization capabilities in geography* (Russian). Bulletin of the Moscow University. Series 5: Geography. N. 2. pp. 22-29.

To create such a 3D model of the tower in 2011. a laser scan of the structure was performed, which recorded the geometry of the structure with high accuracy and spatial resolution. A polygonal 3D model was created based on the point cloud obtained as a result of scanning, the accuracy of which was about 1 cm in a single coordinate system (with a tower height of 160 m).

An example of 3D documentation of a natural object is the project "Virtual Valley of geysers", which was implemented with the support of the Russian Foundation for basic research. This valley is located in the Kronotsky reserve in Kamchatka – one of the largest geyser fields in the world and a unique natural object. The decision to create a virtual 3D model of the valley was made after a catastrophic landslide occurred in 2007, which changed the terrain of the territory and destroyed part of the geysers.

As a result of the work, a high-resolution model of the territory was created, which was later implemented on a virtual globe. Information about this unique natural object was saved as a set of 3D models and an associated information system, which can be considered an example of a developed 3D document.[16]

The increase in the number of tunnels, pipelines, underground parking lots, bridges, overpasses, structures on stilts and other high-rise multi-level buildings are precisely the factors that relegate two-dimensional registration systems to the background and show the advantages of a complex of structured environments in which integrated use of space prevails.

The introduction of a three-dimensional approach in such areas as laser scanning, spherical panoramas, and 3D geoinformation system clearly demonstrates the technological feasibility of a three-dimensional cadastral system.

The three-dimensional inventory is already used and applied in 24 EU countries. The state cadastre of the Netherlands stands out, with an efficient cadastral system and a functioning real estate market. This inventory is professionally maintained and is almost flawless in both theoretical and practical terms. Such an innovation could improve the cadastral system in Russia.[17]

Land law in the Netherlands is governed by civil law. According to the type of cadastral registration, the Netherlands can be attributed to the system of registration of documents (notarial acts), supported by one organization: the Agency for cadastre, land registration and cartography of the Netherlands Kadaster, which is an independent and financially completely independent organization since 1994. Unlike in Russia, where the main units of the cadastre include land plots,

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[16] Leonov AV, Baturin YuM (2014) *3D Document – a new type of scientific and technical documentation* (Russian). Bulletin of the Archivist, N 2. pp. 192-205.

[17] Nikolaeva TV, Nikitin VN (2014) *Cadastre in 3d format* (Russian). Interexpo Geo-Siberia. Vol. 2. pp. 199-204.

buildings, structures, premises and objects under construction, in the Netherlands only land plots are subject to cadastral registration. Information about the legal status of buildings or structures can be obtained from the rights registered on surface areas, and the notarial act required for registration can be accompanied by an analog image of the physical object. Dutch law sets mandatory requirements for determining three-dimensional boundaries when registering premises.[18]

In Russia, work has already been carried out on the development of a three-dimensional real estate cadastre. In 2012, the Russian-Dutch project "Creating a model of a three-dimensional real estate cadastre in Russia" was completed.

The project was developed by the Federal service for state registration, cadastre and cartography, the Federal cadastral center "Earth", the Agency for cadastre, land registration and cartography of the Netherlands (an advanced European organization), the Dutch companies GrontmijNederland, RoyalHaskoning and the technical University of Delft.

The Nizhny Novgorod region was identified as the pilot region for the project, where several pilot sites were selected on the territory of Nizhny Novgorod. The project was implemented from May 2010 to June 2012.[19]

Among the pilot objects for which the prototype of the 3D cadastre was developed were the following:

- Teledom object (9/1 Belinsky street): – multi-level office building with underground Parking, including many premises with various types of registered rights to them. Part of the building overhangs the roadway of the street, while the other part of the building is located above another building located on an adjacent plot of land.
- Object " multi-apartment residential building " (66A Nevzorovykh str.). A multi-story residential building with a more typical 3D configuration, including 88 residential properties and 7 non-residential buildings. Underground Parking is shared. This object is characterized by many copyright holders, and various types of rights and restrictions are registered: property, lease, etc.
- The gas Pipeline facility (Piskunov street) is a medium - pressure gas pipeline that includes underground and aboveground parts and is owned by Nizhegorodoblgaz LLC.

To implement these projects, floor plans of buildings were used, and prototypes were created

[18] https://vipisca.ru/2015/03/sravnitelnyj-analiz-3d-kadastra.html
[19] Kalacheva NI (2013) *Application of the 3-D cadastre with a time component in land and property relations of road management* (Russian). CAD and GIS. 1, pp. 67-69.

in the GoogleSketchUp software package.[20]

A three-dimensional inventory has several advantages. First, it allows you to get a visual representation of a real estate object while simultaneously displaying various information about this object. Secondly, the three-dimensional cadastre increases the efficiency and validity of decision-making in the field of land and property relations, the stability of integrated management of the system of objects, and the transparency of taxation of real estate of citizens and organizations. In addition, this type of inventory creating favorable conditions for investment in the sphere of cadastral relations, significantly increases the rights of property owners and reduces the length of trials and increases the relevance of information contained therein.

But at the same time, there are several legal problems for creating a full-fledged 3D real estate cadastre. In the legislation of the Russian Federation in the field of state registration of rights to real estate and transactions with it, as well as in the field of state cadastral registration, there is no mention of 3D objects and documents that, accordingly, must appear during the creation of a three-dimensional cadastre. In this regard, the introduction of a legal definition of a 3D document and the definition of its legal regime is particularly relevant.

Based on the analysis of the current Russian legislation, we can conclude that the 3D document mode is still not formed, since there are no direct rules governing this object. A developed 3D document can combine elements with different legal regimes.

A developed 3D document can combine elements with different legal regimes. For example, the intellectual rights to the created 3D model may be owned by individuals and organizations that are located or registered not only on the territory of the Russian Federation. 3D models can be protected by various intellectual property rights institutions: as objects of copyright, patent law, and the right to means of individualization of legal entities, goods, works, and services. The use of such models and their infrastructure (data, program code) may be regulated by various types of license agreements, such as the GNU GPL, Creative Commons, and others. In this regard, the most important issue is the choice of the legal protection regime for three-dimensional models.

The question of whether these models can be protected as objects of patent law needs to be resolved, and if so, how three-dimensional models should be differentiated, if not, how the interests of patent holders can be protected in connection with the development of 3D printing.

First, it is necessary to reveal the concept of copyright and patent rights. In accordance with

[20] Deeva AK, Shirina NV (2016) *Three-Dimensional cadastre in the Russian Federation* (Russian). Student scientific forum. Belgorod state technological University named after V. G. Shukhov.

Russian civil legislation, the author of any result of intellectual activity is a citizen who created such a result through his creative work.

In cases where the result of intellectual activity was created by two or more citizens through their creative work, the right of authorship belongs to them jointly and is called co-authorship.

The exclusive right arising as a result of such activity may be transferred by the author to another person by entering into a contract or on other grounds, but the direct right of authorship, the right to a name and other non-property rights may not be alienated, and their protection is indefinite.

Exclusive rights may be protected in different ways, including by bringing a claim for recognition to the person who denies or otherwise does not recognize the rights of the author rather than violate its interests, on the suppression of acts infringing the right or creating a threat of its violation, compensation of losses to the person who wrongfully used result of intellectual activity in the absence of agreement with the owner, which could violate the author's right to remuneration.

Speaking about the exclusive right to result of intellectual activity, it should be noted that the citizen or legal person has the exclusive right to result of intellectual activity or means of individualization (the rightsholder) shall have the right to use such result or such means at own discretion any method not contradict the law.

The copyright holder allows or prohibits other persons to use their intellectual property, and the absence of a ban cannot be considered a permission.

Restrictions on exclusive rights to works of science, literature and art, objects of related rights, inventions and industrial designs, and trademarks may be established if they:

- do not contradict normal use and do not unreasonably infringe on the legitimate interests of copyright holders and third parties;
- do not contradict the usual use of inventions or industrial designs (article 1228 of the civil code of the Russian Federation).

The right to use an exclusive right may be granted through a license agreement, according to which one party, the owner of the exclusive right to the result of intellectual activity or the licensor, undertakes to grant or grants to the other party, called the licensee, the right to use such result within the limits provided for in such agreement. Such a contract can only be concluded in writing, failure to comply with which gives grounds to consider the contract invalid (article 1235 of the civil code of the Russian Federation).

The license may be exclusive, in which the licensee is granted the rights to use the results of intellectual activity without retaining the licensor's right to issue licenses to other persons. When the licensor reserves this right, the license is referred to as simple or non-exclusive. The licensor itself is deprived of the right to use the result of intellectual activity to the extent that the right to use is granted to the licensee as an exclusive license. But this provision is not mandatory, and the contract may provide for other conditions (article 1236 of the civil code of the Russian Federation).

A person who has undertaken to organize the creation of a complex object that includes several protected results of intellectual activity, for example, a multimedia product, acquires the right to use such results on the basis of agreements on the alienation of an exclusive right or license agreements that such a person enters into with the holders of exclusive rights to the corresponding results of intellectual activity. During the use of the result of intellectual activity as part of a complex object the author of such a result retains the right of authorship and other personal non-property rights to such a result (article 1240 of the civil code of the Russian Federation).

Patent rights include intellectual property rights to inventions, utility models, and industrial designs. The authors of such inventions, utility models or industrial designs have the exclusive right and the right of authorship. In addition, the author of an invention, utility model or industrial design also has other rights, including the right to obtain a patent, the right to remuneration for a service invention, utility model or industrial design (article 1345 of the civil code of the Russian Federation).

Copyright protects the form of an intangible object, while patent law is responsible for protecting its content regardless of the form.

If we consider three-dimensional models for 3D printing from this point of view, they are not directly technical solutions protected by patent law. These models can be called a form of expression of the corresponding solutions. Thus, three-dimensional models for 3D printing cannot be objects of patent law. At the same time, the production of goods using 3D printing, which embody, for example, inventions or utility models and industrial designs, as well as their further introduction into civil circulation violates the exclusive right to a patent. The objects of patent rights include the results of intellectual activity in the scientific and technical sphere that meet the established requirements for inventions and utility models, and the results of intellectual activity in the field of design that meet the established requirements for industrial designs.

In the current legislation, the concept of a single technology is closest to the legal regime of a 3D document. A single technology may contain the results of intellectual activity that are not subject to legal protection under patent law, including technical data and other information.

On the one hand, we can conclude that the most appropriate is the copyright regime for protecting 3D models for 3D printing, since many countries are fighting Internet piracy at the legislative level.

On the other hand, there is another problem. To be protected by copyright, an object must have a creative character, and the creative character must be inherent in its form.

It is also important to note that the term of protection of copyright objects significantly exceeds the term of protection of patent objects, which may hinder the development of the economy, science and technology.

Thus, we can conclude that the 3D model needs a qualitatively new mechanism of legal protection, which would combine copyright in relation to the suppression of illegal distribution of objects on the Internet,and more democratic terms of patent protection.

To date, there is not a single legislative act in the domestic legislation that directly regulates issues related to a 3D document. Only a small number of state Standards have been adopted, which only indirectly affect issues related to 3D documents. In this regard, it is proposed to introduce the concept of a 3D document or 3D model in legislative acts. It is advisable to select a 3D document as an independent object of the protected result of intellectual activity and a means of individualization.

A 3D document cannot be effectively protected either as an industrial design or trademark, or as a database, since it differs significantly from the latter in both the methods of creation and the purposes of use. That is why it needs an independent method of protection and should be included in article 1225 of the Civil code of the Russian Federation.

As an example of recent changes made in this area, which resulted in the allocation of a new object for the protection of intellectual property results and means of individualization, we can cite the recently adopted amendments that introduced such an object as a geographical indication. Such an indication is understood as a designation that identifies a product originating from the territory of a geographical object, a certain quality, reputation or other characteristics of which are largely related to its geographical origin. A geographical indication is recognized as such and placed under protection after its state registration, the exclusive right is certified by a certificate.

By its nature this object is like the appellation of origin of goods, but between them there are several differences, such as the lack of need for a geographical indication to a special property of the product.

This situation has a lot in common with a 3D document and an industrial design, so a 3D document is primarily an external solution, but at the same time it has a number of technical characteristics that are not important for determining the novelty of an industrial design.

Therefore, a 3D document needs its own legal protection mechanism. It is advisable to proceed by analogy with databases and programs for electronic computers. A 3D document must be classified as a copyright object regardless of the method of its creation and the nature of the model, but at the same time it must be possible to register the created 3D model with the state.

Copyright within the meaning of the fourth part of the civil code refers to intellectual rights to works of science, literature and art. Computer programs are works of literature for the purpose of copyright protection. Given the importance of the visual component of a 3D model, it is possible to equate it with a work of art by analogy.

This way, the authors of all 3D documents will get the rights:

- Exclusive right to a product;
- Copyright;
- Author's right to name;
- Right to inviolability of the work;
- Right to publish a product.

In addition, the copyright holder will be able to provide more effective protection of their interests in the event of disputes, as well as receive additional income from the sale of licenses.

To register a certificate for a 3D document, you can set the provision of such documents in addition to the application as a brief description of the model with a limit on the number of characters up to seven or five hundred, as well as, by analogy with the registration of an industrial design, a set of 3D model images that will help identify the model and other materials that reveal the essence of the 3D document.

The fee may also be set at the rate of three thousand for individuals. After reviewing the application, the person must also be issued a special certificate certifying their exclusive rights to the 3D document. It is advisable to create a special Register that considers the rights to 3D models, in which data about registered documents will be entered.

Conclusions

It is also necessary to amend Chapter 70 of the Civil code, indicating the copyright of the manufacturer of the 3D document, as well as Chapter 71 on related rights, adding a 3D document after the paragraph on the rights of the database manufacturer.

In addition to changes in legislative acts, it is necessary to develop recommendations for standardizing the use of 3D documents, since the law cannot contain all the issues related to the creation and use of such documents.

Regarding the legal norms, it should be noted that in General, the issues of electronic document management and 3D modeling are not sufficiently regulated by current legislation, and the main part of the norms and definitions is contained in various state Standards.[21]

For example, the General requirements for creating text documents that are already familiar to us are set by state Standard 7.0.97-2016. The concept of an electronic document as a document whose information is presented in electronic form is contained in state Standard R 7.0.8-2013. National standard of the Russian Federation. System of standards for information, library and publishing. Clerical and archival work. Terms and definitions. The closest to 3D technologies are state Standard R 57558-2017 / ISO / ASTM 52900: 2015 Additive manufacturing processes. Basic principle. Part 1. Terms and definitions, which contains definitions of 3D printing, 3D printer, and state Standard R 57563-2017 / ISO / TS 12911: 2012 information Modeling in construction. The main provisions for the development of standards for information modeling of buildings and structures include the concept of an information model.

An information model is defined as an object-oriented parametric 3D model that digitally represents the physical, functional, and other characteristics of an object (or its individual parts) as a set of information-rich elements. However, this document does not contain the concept of a 3D model.

State Standard R 57590-2017. Additive manufacturing processes. General requirements defines the concept of 3D CAD modeling as the process most commonly used in design to create a digital 3D model. The starting point can be an image of a product that takes shape and becomes more and more defined directly on the computer screen, or a previously created image of an object in the form of sketches, drawings, etc., which are then simply converted to 3D data. The product volume can be described using two different methods or a combination of both. An object consists of either elementary volumes (shapes) (for example, a rectangular parallelepiped. a cylinder, cone, sphere, etc.) that generate a real object using a sequence of logical operations, or a volume that describes its neighborhood of boundary surfaces and the location of materials relative to boundary surfaces.

[21] Zakharova MI (2019) *Legal regulation of a 3D document and its application in the business environment*. Intellectual property in the modern world, pp. 91-93

State Standard R 57591-2017. "Additive manufacturing processes. Data processing " contains an extremely concise definition of 3D-three-dimensional design, which does not reveal its features.

Typically, a detailed definition of 3D can be found in local documents of organizations involved in modeling, design, and so on. Such definitions may also be contained in technical specifications and other appendices to contracts.

For an electronic document management system with 3D participation, the concept of a Common Data environment (CDE) as a single source of reliable information for all project participants can be useful. CDE is based on procedures and regulations that effectively manage the iterative process of developing an information model and issuing project documentation to achieve full integration and spatial coordination of data/information from all participants and sources of this information.

An electronic document is any text, sound, image, or other electronic information stored in the original format for the application in which it was created.

The absence of such definitions in regulatory legal acts gives rise to discrepancies in the definition of the same concepts, and therefore it is advisable to Supplement Article 3 state Standard R 7.0.97-2016. National standard of the Russian Federation. System of standards for information, library and publishing. Organizational and administrative documentation. Requirements for the design of documents with definitions for certain types of electronic documents, including 3D.

It is necessary to develop a separate state standard dedicated to the direct creation of 3D documents, which would resolve all technical issues and problems of the conceptual apparatus.

First of all, it is necessary to develop a General definition of a 3D document based on the terms discussed earlier, namely: "a 3D document is an electronic document containing a representation of the geometry of objects and their location in space (in X, Y and Z coordinates)".

Separately, the concepts of 3D models can be introduced as images of an object, its geometry and location in space (in X, Y, and Z coordinates), BIM, or an information model for construction and design purposes. The latter can be understood as a digital representation of the physical and functional characteristics of an object through a set of elements and information about the design, construction, operation, modernization and demolition of a construction object. It may be appropriate to introduce the concepts of 3D models obtained using different technologies, as well as requirements for the format and quality of created 3D documents.

The development of technologies inevitably leads to the introduction of 3D documents in almost all areas of human activity. 3D modeling has become a unique tool that allows you to create a wide variety of objects, from simple models of geometric shapes to human organs.

In conclusion, it is worth noting that today cadastral registration is still carried out based on a two-dimensional map. In Russia, although separate projects are being developed for the three-dimensional representation of spatial objects and the creation of 3D models of cities, a unified system has not yet been created due to the lack of the necessary legal framework.

The capabilities of the three-dimensional cadastre contain a huge potential for managing the development of territories by state and local authorities, as well as planning and controlling the production of many economic works, such as construction, laying communications, and repair work in the housing and communal services system.

The current stage of development of land relations without significant changes in the field of real estate cadastre, land management and land management, innovative activities both in Russia and abroad cannot be carried out at the required pace.

The research conducted in the article allows us to come to the conclusion that it is necessary to create a framework for regulating 3D documents in Russian legislation. Further development of this Institute is necessary. To work on improving legislation in the field of 3D documents, it is necessary to involve not only interested state bodies and departments, but also technical specialists, including for the development of state standards.

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2. Geoinformation system as a controlling tool for External State Audit Bodies

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Abstract
The Author justifies the needs of introducing Geo-Informational Systems into the daily activities of The External State Audit Bodies by revealing the concepts of both controlling and digital audit applications. With the development of introducing digital auditing into The Accounting Chamber of The Russian Federation along with Russia's leadership role in INTOSAI, the time has come to modernize our information systems for the 21st century and beyond.

Keywords
External State Audit Bodies, Digital Earth, Geoinformation system.

Introduction

The idea of digital audit is actively developing both at the level of the private sector and at the state level. The use of information technologies in the process of performing audit activities should increase its effectiveness.

Discussion

The Digital Audit uses new technology to deliver high-quality audits that serve the public interest by enhancing trust and confidence.

Today, digital audit is being developed and applied in two directions:

- in private companies. For example, PWC, EY, KPMG;
- in the activities of state financial control and state audit bodies.

INTOSAI (International Organization of Supreme Audit Institutions) occupies a special place in this process.

At the XIII Congress of the International Organization of Supreme Audit Institutions (INCOSAI) in Berlin in 1989, The Working Group on Information Technology Audit (WGITA) was created to address SAI's interests in the area of IT Audit. Supreme Audit Institutions (SAIs) of 39 countries represents the Working Group as of March 2013 (INTOSAI, 2020).

The WGITA fulfills its mission and mandate by implementing the triennial work plan which consists of the various goals and projects. Projects are selected after reviewing the needs of SAIs

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and the deliverable range from the best practice guides to website related information and other audit material. It is the dedication and effort of individual SAIs, who lead and support projects, as project leaders and members, that make the WGITA work.

The mission of the WGITA is to support SAIs in developing their knowledge and skills in the use of information technology related audits by providing information and facilities for exchange of experiences, sharing best practices, and encouraging bilateral and regional cooperation among Supreme Audit Institutions (SAIs).

From the perspective of the development of the audit function, Supreme Audit Institutions (SAIs) worldwide have undertaken increasingly important duties in strengthening accountability, promoting good governance, and monitoring the implementation of sustainable development goals in their respective countries. The XXII Congress of the International Organization of Supreme Audit Institutions (INCOSAI) in 2016 adopted "How can INTOSAI contribute to the UN 2030 Agenda for Sustainable Development, including good governance and strengthening the fight against corruption?" as the topic for Theme I. In its Strategic Plan 2017-2022, INTOSAI mapped out a clear vision to "promote good governance by enabling SAIs to help their respective governments improve performance, enhance transparency, ensure accountability, maintain credibility, fight corruption, promote public trust, and foster the efficient and effective receipt and use of public resources for the benefit of their citizens." In the era of Big Data, SAIs are aware of the importance of information technology to improve audit quality so as to help their respective countries implement their sustainable development strategies.

Digital audit makes it possible to follow the trace of economic activities in digital circumstances, so that SAIs can evaluate the performance, transparency, and accountability of the public sector in a more accurate and prompt manner, and ultimately facilitate the implementation of the United Nations' 2030 Agenda for Sustainable Development.

One of the themes of INCOSAI XXIII held in Moscow in 2019 was the role of information technologies in public administration. The Accounts Chamber of the Russian Federation proposed this topic for consideration by the INCOSAI understanding that quality control of public investments in the modern world is impossible without the introduction and application of advanced digital solutions and analytical methods.

The international audit community recognizes the need for "an efficient use of the opportunities brought about by the technological progress." In particular, it is Big Data received from public bodies, progressive analysis of digital data as well as the artificial intelligence and other solutions at different stages of an audit.

The accounts chamber of Russia will be able to switch to digital audit within three years. This was announced by the head of the Department Alexey Kudrin in 2018. "First of all, this is the digitalization of financial audit. Much of this work is already based on the results of an automatic analysis of the electronic budget, but in general, we will seriously advance the analysis of the work of all institutions. We will cover significantly more, even without going out for on-site audits. He state that, It will take about three years to make serious progress in this area to put it into permanent practice with expanded coverage", Kudrin said (TASS.ru, 2018). Digitalization of the audit will significantly reduce the number of violations allowing the audit chamber to switch to a preventive mode of operation.

In 2015, the audit chamber created the official website of the Russian Federation in the information and telecommunications network "Internet" for posting information on the implementation of state (municipal) financial audit (control) in the field of budgetary legal relations. The creation of this portal is aimed at coordinating the activities of controlling financial authorities and informing citizens about the activities of control accounting bodies.

As part of the development of the idea of implementing information technologies in the activities of higher audit bodies, it is advisable to use GIS.

A geographic information system (GIS) is a system for collecting, storing, analyzing, and graphically visualizing spatial (geographical) data and related information about required objects. GIS integrates many types of data. It analyzes spatial location and organizes layers of information in visualizations using maps and 3D scenes. With this unique capability, GIS reveals a deeper understanding of data such as patterns, relationships, and situations, helping users make smarter decisions (ESRI.com, 2020).

GIS combines many different types of data layers using spatial arrangement. Most of the data has a geographical component. GIS data includes images, objects, and basemaps.

Spatial analysis allows you to assess suitability and capabilities, evaluate and predict, interpret and understand, and much more, providing new perspectives to your understanding and decision-making process.

Apps provide a focused user experience to get the job done and bring GIS to life for everyone.

Governments collect and manage vast amounts of data - all tied to location. Maps and spatial analysis are quick to understand, so it's easier to use. Making decisions based on data that improve the quality of life is important for national, state and local governments. The use of GIS by government agencies contributes to improving the quality of controlling and the effectiveness of management decisions. The control and accounting authorities of Russia should use GIS for monitoring and controlling the expenditure of budget funds and for more detailed budget planning.

Geoinformation systems in the activities of Supreme Audit Institutions consist of 4 parts: Insightful analytics, Simplified sharing, Rapid data collection, Coordinated response.

Insightful analytics which is the ability to create and share easy-to-use maps and analytics that improve everyone's understanding. Analyze complex issues and reveal hidden patterns in data. Facilitating informed decision-making.

Simplified sharing the sharing of maps and analytics securely with staff or citizens to support smart initiatives. Dashboards, story maps, interactive web maps, and infographics provide intuitive and effective communication tools.

Rapid data collection the simplification of data collection on any device, including smartphones, drones, and Internet of Things (IoT) sensors. Quickly assembles data from real-time feeds, multiple databases, or any online public data repository.

Coordinated response that covering the Synchronization of first responders with real-time status data and maps in a single, unified dashboard. Acts with confidence in dynamically changing situations to speed assistance and to keep people safe.

Conclusions

The use of GIS in state audit will allow you to track the effectiveness of budget spending in real time. The accounts chamber will be able to see the process of spending Federal budget funds and implementation of state programs in each region of the country, using artificial intelligence to analyze information and develop recommendations for improving internal financial control and audit.

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3. "Digital Health Earth": towards a global healthcare management geolocating human health condition by means of space technology

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Abstract

Healthcare providers such as the World Health Organization, transnational and global health initiatives, the national healthcare systems, down to the smallest villages and individual practitioners and professionals could benefit from geo referential data and metadata and 3D digital assets provided by space technology. Health prevention and literacy programs, mortality and morbidity rates, including contextual statistical data about populations and territories are being already produced and accessible. The hypothetical frame of a Digital Health Earth hereto presented could be performed as the interoperability of 3D representations of sectors of territories and geolocalized layers about health and environment. SDG Goals crossed with WHO programs and available data can become the premises for the design and development of a global representation of healthcare situations, highlighting priorities and disseminating data by intuitive and interactive modes of visualization as it is already happening with 2D dashboards about COVID-19 pandemic. Healthcare practitioners, professionals, health managers, but also patients, proxy, social workers, laypeople, stakeholders and media could benefit from visualizing and comparing Digital Earth health data. Concerns about privacy, digital divide and social exclusion from primary care services and how quality of lives might occur are considered here. As a consequence of Space Technology, especially for its connection with the Satellite industry, Digital Health Earth, will contribute to the development of a new added value economic branch inside the increasing market of the Space Economy Revolution.

Keywords

Digital Earth, health, neogeography.

Introduction

Since the Corpus Hippocraticus from the 5th Century B.C. empirical evidence has related medicine and healthcare to places. Peculiar situations and local conditions have always helped in healing and taking care of people, involving either practitioners, or laypeople. In fact, according to World Health Organization (WHO), health can be defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO.int, 1948). Nowadays and as evolution of the paper cartography, GIS can support quality of life given its usefulness in connecting data about phenomena, happening on local spots and at global level.

Science of medicine, surgery and healthcare have developed statistical means and records in order to understand phenomena and develop patterns, starting at local level by local resources. Globalization and networks could combine individual efforts and experiences into a global digital

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frame to provide information about health data, resources and actions.

Neogeography as an implementation of a new scientific principle and a summa of technological achievements (Turner, 2006) applied to healthcare could bring a new and integrated way to deliver health information literacy, produce research, provide care and enact prevention all over the globe. This might be possible starting from implementing world programs in health for Earth frame. In June 1992, at the Earth Summit in Rio de Janeiro, Brazil, more than 178 countries adopted the Agenda 21, a comprehensive plan of action to build a global partnership for sustainable development to improve human lives and protect the environment by 17 Sustainable Development Goals. Most of such goals feature a clear connection between health and environment, but still today is hard to harvest data about SDG and their impacts, probably as the quantity of data to be crunched are not providing yet the useful leverage to *ad hoc* policies to face the environmental disruption and the consequences on human life and condition.

Digital technologies can provide solutions to pursue such goals. Changes in the last decades must be monitored by *ad ho*c technologies (Shupeng & van Genderen, 2008), especially on the quality of life and conditions about the habitat coming from the interaction with humans and between humans. It is be known how much the interaction of users with digital applications can be represented and tracked by data (Butler, 2006).

According to the International Society for Digital Earth (ISDE), Digital Earth is the result of "digital technologies to model Earth systems, including cultural and social aspects represented by human societies living on the planet" (ISDE, 2012). The concept of Digital Earth traces back to 1998 when Al Gore presented his visionary concept of a Digital Earth as a "a multi-resolution, three-dimensional representation of the planet, into which we can embed vast quantities of georeferenced data" (Gore, 1998). Talking about geospatial data, Gore outlined the difficulties of taking advantage of this vast amount of data. He envisioned applications where "information can be seamlessly fused with the digital map or terrain data" allowing the user to move through space and time. To achieve this vision, a collaborative effort from government, industry, academia and citizens is needed.

The Digital Earth might be defined as a global strategy (Chen, 1999) highly related to Geoinformation Science (Chen, 2004). A decade after the Gore's vision presentation, a Digital Earth project was presented. Since then, a global effort started developing a technology framework to preserve the planet in support of human societies (Liu, et al., 2020).

Therefore, the project of Digital Earth (Goodchild, 1999) might benefit as well from adding a health perspective to the project.

Health data driven dashboards towards 3D representation

Digital technologies are already producing data about access, productivity, networks, reputational rates, areas, or other phenomena about users and their offline or online activities on websites, social network sites, or platforms; such layouts of multiple representations are called dashboards. Dashboard could be defined as a “visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance” (Few, 2006). In our case, a possible definition for an online health dashboard is a two-dimension interface that provides visualization and interaction with data about health in a given area of the world, in a specific time span. During these last months, the design and adoption of dashboards have increased a lot, as they can monitor and represent pandemic situations and statistics about rates of infection, casualties and healed cases from the virus.

It can be stated that, due to the pandemic itself, the connection of information age and real time health issues have been cleared and made computationally working (Geraghty & Frye, 2020). A vivid example comes from a former project of John Hopkins University developing a dashboard able to crunch data and provide real time data queries about the covid pandemic.

Further examples of health dashboards created to monitor COVID-19 can be considered Italian dashboard (FBK.eu, 2020), thanks to a partnership with WHO (Tangcharoensathien, et al., 2020), including visualizations about collective sentiment and psychology, social bot pollution and news reliability, and the one built by ESRI for the WHO directly (WHO.int, 2020a). The case of the WHO is very interesting as it entails three different web resources providing infodemics: a dashboard, the website and a news map.

Such dashboards provide global data about COVID-19 thanks 2D mapping of data about phenomena.

Health analysis of the transport systems in pandemic age

Based on a report made by ICAO, it demonstrates that air transportation is hugely impacted and has a direct effect on the transmission chain of the novel Coronavirus COVID-19 (ICAO.int, 2020). Most countries in the world imposed a lockdown measure to curb the problem where most of the international borders were closed between March till June. This measure had cost thousands and even millions of dollars of business loss. Following the ease of the lockdown to promote business activities, most countries started to implement new guidelines on travel practice to avoid or at least minimize the risk of COVID-19 resurgence. Therefore, the handling processes at the airport will be significantly changed as a consequence of the pandemic (Schultz, Sulaki, 2020), whereas aircraft seating arrangement will change in order to maintain the social distancing and minimize possible contacts amongst passengers and this will result in a slower transportation process at the airport. Thus an analytical approach to solve the problem of seating arrangement and passengers' movement in the aircraft during boarding was provided. Before the emergence of COVID-19 pandemic, the airlines industry has been studying on the most effective, cost saving aircraft boarding for passengers giving consideration on passengers' expectations as well as luggage and cabin bags handling which can be time consuming if not done systematically. Thus, it is reckoned that the new normal practice will drive the aviation industry to evaluate further the handling of passengers and airport management to meet the criteria of social distancing in order to minimize infection transmission.

Prior to data that could be obtained from aviation industry through airport management assessment, public health practitioners and epidemiologists can benefit the data of movements of passengers, cabin bags and luggage handlings at the airport and on board of aircraft, to evaluate the risk of transmission and predict the likelihood of infection spread globally. However, the movement of people travelling all over the world is fluid, thus a real-time data will be helpful. Therefore, a real-time Digital Health Earth that shows the movement of travelers at airports can be beneficial for public health practitioners and epidemiologists to predict the transmission rate and its propensity. Besides that, the real-time data can also be used by the governmental bodies as part of their considerations in developing international border policy which may change from time to time, due to the ongoing dynamic circumstances. In addition, general practitioners and travel medicine doctors can largely benefit this information as well in providing advice to their patients (provided that the data is accompanied with public health advice). It is not impossible that in the future, the study of people's movement that contributes to infection transmission based on Digital Health Earth will be part of adjunct syllabus in epidemiology or public health study.

The data will comprise of patterns of movement at the airport on boarding and landing, the routes of flights and the origins of flights. If such detailed information could be gathered and systematically grouped, public health practitioners and epidemiologists may be able to evaluate the import and export of disease transmission. In any disease outbreak, information is power. Nonetheless the data collected in Digital Health Earth must be regularly updated to get as accurate as possible to deepen our understanding of transmission patterns, severity, clinical features and risk factors for infection which were unknown at the beginning of the COVID-19 outbreak.

Interoperability, sustainability and visions for a Digital Health Earth: a global approach

WHO's actions could be represented as visible layers on a map if considered according to resources as the description of local and global phenomena about specific issues. Such resources are those available as WHO programmes, which could easily be eligible as layers: Alcohol and health, Child health, Cholera, Environmental health, Health systems financing, HIV/AIDS, Immunization, Malaria, Maternal and reproductive health, Mental health, Neglected tropical diseases, Noncommunicable diseases, Resources for the prevention and treatment of substance use disorders, Road safety, Tuberculosis, Urban health, Tobacco control, Violence prevention, Violence against women, Water and sanitation.

There are further issues that define public health issues as a connection between globalization and health (Labonte, Laverack, 2008), like global threat, priority settings, and health promotion (Lee, 2003). Especially in the field of Health Promotion, the World Health Statistics 2020 (WHO.int, 2020b) summarizes recent trends in life expectancy and reports on progress towards the main health and health-related Sustainable Development Goals (SDGs) and associated targets. It also assesses the current availability of those data, and describes how WHO is supporting countries to improve health information systems and global health security. The 2020 edition also includes four indicators (relating to poliomyelitis, hypertension and obesity in adults and school age children) from the Thirteenth General Programme of Work 2019−2023 (WHO.int, 2020c).

Digital Earth is envisaged as "a common platform to support national and international cooperation for global sustainable development, and a newly developing point of economic growth and social well-being" (ISDE, 2014).

The concept of a Digital Health Earth is here sketched and categorized according to present different possible needs and existing resources, means and goals and could be assessed within the context of Digital Earth concept, developed since 2006 under the umbrella of International Society for Digital Earth (ISDE) as a “non-governmental and not-for-profit international organization for promoting international collaboration towards the achievement of Digital Earth through academic exchange, science and technology innovation, education, and international collaboration” (ISDE, 2014).

Digital Earth is an integral initiative, intended to provide situational awareness as an ultimate interdisciplinary collector of data: “relying on collaborative efforts between Earth sciences, geospatial information and space sciences, Digital Earth aims to monitor and forecast natural and human phenomena on our planet” (Giuliani, Wang, 2019). Life data is vital for this purposes, therefore among the natural and human phenomena health and environmental conditions for human life should be considered. In order to save lives, take care of patients and run prevention programs, but also to increase the quality of life and monitor human health conditions and environmental situations in normal and emergency times a global interoperable and accessible solution is needed.

Human health be a global issue that must be tackled at global level; national (Boulos, 2004) and continental solutions (Gaughan, et al., 2014) for the Digital Earth project (Annoni, et al., 2011) are already out there. Spatial Explicity of data (Balk, et al. 2006) and global health needs and programs need now, more than ever, a transnational and transcontinental approach, and in the end a global approach.

COVID-19 Pandemic has shown us that restrictions to daily life to decrease risks mine the quality life at large. Computer supported activities and contexts out of activities of daily life can be data driven, i.e. quantified, monitored, crunched by emerging techniques such as dashboarding real life information, social network analysis in applications (SNAA), databasing, decision making and information.

Is time to adopt a global approach about health issues to simplify and make visual how research and experimentation in medicine and care include “uncertainty and probability” (Goodchild, et al., 2012). Information and Communication technologies can as well include the engagement of the public in such proposal by crowdsourcing mapping (Heipke, 2010) and data sharing.

Such hypothetical frame for a Digital Earth for health (Craglia, et al., 2012) should fill the lack of healthcare frame included as global issue in Al Gore’s vision from the 90’s.

Conditions come from the interoperability on georeference public health issues statistics (Cromley & McLafferty, 2012), the technique of Geocoding Health Data (Rushton, et al., 2008), with the perspective of the WHO actions according to 17 SDG and other possible goals.

On the side of observing in real time phenomena about collective behaviour of populations, Earth observation (Anderson et al., 2017) and applications are already available, such as the Gridded Population of the World (GPW) collection that models the distribution of human population (counts and densities) on a continuous global raster surface (CIESIN, 2016).

Geographical application to monitor infections should be available as well on large scale (Linard & Tatem, 2012), but also on global scale. Moreover, seamless integration of heterogeneous datasets generalized in the different scales is vital, therefore implementation of scale-less visualization principle become mandatory.

A visual 3D approach would make possible granting information and research according to big areas as well as small places, and even according to multi temporal (Freire, 2016) and global grids (Goodchild, 2000) for the study of population at global level (Pesaresi, et al., 2015; 2016) to access data about health conditions comparable to other data provided according to different geographical regions or historical times. The three-dimensional representation of high-rise urban development is extremely important for studying the spread of infections using man-made mechanisms, such as legionnaire's disease (Jomehzadeh et al, 2019). Of particular importance here is the creation of a highly accurate photo-visual model of the urban environment (Jackson, Simpson, 2020; Baturin et al, 2020) that allows for the precise localization of health and contextual information.

For instance, interdisciplinary approaches of population data (Deichmann, 2001) and census data (Doxsey-Whitfield, 2016) have become some requirements for Global Human Settlement Layer (GHSL) including parameters from the SDG in terms of socioeconomic data (Corbane, et al., 2017), the urban spatial print at global level (Melchiorri et al., 2018), and volunteer commitment (Goodchild, 2007) to contribute to map crisis events (de Longueville, 2010) and the availability of complex and interactive mapping. On the side of mapping there is already evidence of development on accuracy in mapping about population for public health uses (Hay, et al., 2005) in terms of validation on multi-temporal layers for land data for the benefit of the public involvement (Leyk, et al. 2018).

What is needed now is the involvement of institutions and research, the interoperability of scattered technologies and solutions around the globe adopted at local levels, a global health policy for Big and Open Data.

Nowadays, data intensive research is possible (Hey, 2009) and should find support around the world scientific medical community. A digital Health Earth project could solve Big Data problems

(Guo et al., 2014). In terms of Big Earth Data there is the need to enwide applications and fields of human activities, such as healthcare although not yet envisioned (Guo et al, 2017).

In a innovative Digital Earth perspective (Goodchild, et al., 2012) solutions and means must stay inclusive to people, and in this case also to patients. Digital Earth project itself should be the result of multiple uses (Goodchild, 2008). Mapping health situations could be pushed on a 3D level thanks also to a data global policy about Big & Open Data (B&OD).

The model for a digital twin of Earth related to health should, therefore, be a multidimensional, multiscale, multitemporal, and multilayered information system able to provide consistent visual data about health around the globe in all scales simultaneously.

WHO might be eligible as a favourable provider or endorser for a Digital Health Earth, given its global advocacy and historical/institutional role as international organization for health prevention and action for care in the whole world.

Geolocalization and health related ethical questions

Ethical requirements for Digital Earth (Georgiadou et al, 2020) and especially an ethical tension between the value of GIS in solving health-related issues and privacy concerns cannot be denied; health data and applications remain limited. However, there is an ongoing debate about licensing health data and explicit how big data (Ienca, et al., 2018) could become a benefit for public health in the coming future, given the strong practical example during the pandemic.

Application of GIS in public health and social services programs would make the difference in tackling emergencies and actions. Other applications would be of support to hospitals, but also insurance companies to detail and update statistics in order to profile and evaluate risks.

Global care and healthcare outcomes could be improved in the following ways: Determine access to care, connecting people with local resources, determine variation in health care services and outcomes, identify vulnerable populations – useful in emergency situations or in the regular course of public health work., understand clusters of disease and its causes, collect mobile data, providing new insight for better understanding of homeless populations and directing resources, where needed, More timely and efficient allocation of resources, Improving our response to disasters and disease, Strengthening collaboration between agencies and healthcare.

What is sure is that GIS data interoperability with healthcare systems, facilities and professionals is to breakthrough what traditional healthcare solutions can’t detect (CDC.gov, 2012).

Geolocalization and health related ethical questions

Main goals for a digital Health Earth would be to provide information about the main Who dimensions of intervention on world population:

- Morbidity, its Causes, and what actions;
- Mortality, its Causes, and what actions.

Sustainable Development Goals (SDG) such as the Goal#3 “healthcare and ...quality of life” should address the development of a Digital Health Earth project intraoperative and integrated with the other neo geographical assets and Global issues networks in a global health perspective. Open data policies for health data should be fostered and education and training on Digital Earth applications for healthcare should be provided. Real-time data could be provided in case of risk situations, or natural disasters. Digital Health Earth could be used for education and to inspire future physicians and nurses and foster cooperation among hospitals, communities and institutions to increase safety and prevention practices.

While the entire world understands the benefits of using visualization for better health outcomes, countries which are showing immense progress in this realm are New Zealand, some states in US and Scandinavian countries. A flagship undertaking in this area is a new partnership focused on geo-health between the University of Canberra and the Dasman Diabetes Institute (DDI). The aim of the initiative is to tackle a serious public health concern – the disturbing prevalence of type 2 diabetes in Kuwait. Dr. Coffee and his team are building a geo-health data lab in Kuwait, which will help them in studying the variability in the disease’s prevalence in the country, and thereby identify and analyze how location contributes to the situation (Geospatialworld.net, 2018).

The adoption of available GIS systems can provide global tools for the application of digital health earth concept.

New disciplines and new professions

All the technologies and capabilities required to transform this vision into reality and to build a Digital Earth are already available, such as: Computational science, Mass storage, Remote sensing imagery, Sensors, Broadband networks, Interoperability, Metadata. All this is already possible as solutions to global public health surveillance vision (Boulos, 2004). GeoAI opens up big opportunities and applications in health and healthcare, as location plays a key role in both population and individual health. Several disciplines within the domains of public health, precision medicine, and IoT (Internet of Things)-powered 'smart healthy cities and regions' are benefiting from GeoAI, e.g., environmental health, epidemiology, genetics and epigenetics, social and behavioral sciences, and infectious diseases, to name but a few. (Boulos, 2019)

The vision of DE should not be solely about space and spatial relations but also about place, culture and identity, spanning the entire physical and virtual space (Craglia et al. 2012). This new vision is still only slowly being adopted and there is uncertainty related to the needed competencies required in the preparation of future DE specialists. The future of DE should be planned according to education and training.

Education and training provides a liberal arts background, methodologies, and depth as well as breadth of thinking. The human is ultimately where knowledge work is done and those insights are produced in geospatial intelligence. It is dependent on the geospatial analyst's meta-knowledge.

The Training/Professional development should be built on education and expanding the knowledge base for increased performance. Training and education might happen in the digital world as part of the Digital Health Earth itself. The training and professional development should focus on the human-machine team where there is a focused effort to develop information about relationships among disparate objects and events. In terms of future professions, DE specialists for medicine, surgery, healthcare (such as nursing, social workers and community managers for public health education) and professional development can be implemented in technology, leadership, research and education itself (Alderson et al, 2020).

Conclusions

Data and reports about healthcare statistics and risk management around the world benefit from Digital Earth Project. It is important to start sketching and then design a possible layout for the implementation of a Digital Health Earth in the Digital Earth project. Although, there are several ethical implications, given aspects of human health related to privacy concerns and biological rights, spatial health related statistics (Waller & Gotway, 2004) and community data. To be useful, data should be available in real time thanks also to emerging forms of citizen science and open publication of health data by users themselves, that would make out a Digital Health Earth accessible for everyone, with data uploading and downloading.

Our suggestion is that the Digital Health Earth becomes a new structured area of research to produce benefits in different domains of the human health management. Digital Health Earth should include at least the following sub-domains:

- Visualization of health data both in 2D, 3D and virtual/augmented reality format.
- Geolocalization of patients.
- Visualization of environmental data which can have an effect on human health.
- Supply Services for public and private healthcare.
- Monitoring of population flux and related diseases, epidemic.
- Integration with available satellite and space technology for the purpose of human health management.
- Global scenarios for simulation based on data driven public health and statistics about medicine, surgery and healthcare interventions.
- 3D Healthcare literacy and dissemination of data for education, training and information to the public.
- Design of the technology to support any of the Digital Health Earth application.

Peculiar situations, such as social exclusion or missing healthcare data would be accountable (Carr-Hill, 2013) and appear much visible substituted or integrated by data provided by samples or surveys, for instance (Carr-Hill, 2017).

Also an automated speaking version for the visual unpair should be provided in order to include as many users as possible.

WHO programs, research centers, national plans for healthcare, disaster management, public health data and other institutions should provide elements to build an interoperable representation at global level of different situations in different places at different times. This representation could be called Digital Health Earth.

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