White Paper

Personalized Medicine with Digital Twins

By Neal Solomon
Founder and CEO
Gemini Corp.

Gemini Corp.
1 Sansome St., Ste. 1400
San Francisco, CA. 94104

(415) 334-5600

Digital Healthcare Challenges

The world is in the midst of two broad scientific revolutions. The first scientific revolution involves information technology. This revolution includes computing, communications and artificial intelligence. We appear to be in the early stages of an AI boom. The second scientific revolution involves the biological sciences. The unravelling of the human genome has provided dramatic biological discoveries with applications to biomedical technologies, including genomics, proteomics, bioinformatics and epigenetics.

The combination of these two simultaneous scientific revolutions has yielded extraordinary technological and business opportunities. The healthcare industry in the U.S. is about $5T a year or about 20% of the U.S. economy. Discovering ways to apply advanced information technologies to the healthcare industry has produced the emerging market of digital healthcare. The digital health market is nascent, but rapidly growing, consisting of numerous market segments – from telehealth to electronic health record management and from fitness and health apps to wearables – that are growing from about $300B in 2020 to a projected $1.5T by the end of the decade. By 2030, digital health will be about 10% of U.S. healthcare.

While numerous digital health market segments represent simple data processing tasks, a larger and more complex set of healthcare problems require *intelligent healthcare solutions*. These advanced digital healthcare categories involve personalized medicine, diagnostics modeling, therapeutics modeling, automated personal medical assistants, medicine monitoring, IoT data analysis, disease management and automated patient relationship management. These larger digital healthcare problems are solved by applying AI and analytics to biomedical challenges in

order to customize patient solutions. The personalized medicine market (nutrition, med care, diagnostics and therapeutics) is growing from $540B in 2022 to $925B in 2030.

AI is applied to individual patients by applying digital twins – advanced modeling – and individuals' personal health assistants to help patients manage their own healthcare. AI is also applied to digital healthcare in order to enable physicians to use digital twins to solve complex diagnostic and therapeutic medical challenges. Finally, AI is used by enterprise managers to track and model employee healthcare. AI technologies are highly specialized, but despite their complexity, healthcare is probably the best application for AI. Yet, few have applied advanced AI technologies to healthcare in any meaningful way.

The digital healthcare industry presents a set of challenges and opportunities. Regarding individual *patients*, patient health data tends to be disunified and fragmented, which is inefficient. What are needed are technologies that provide an integrated solution that guides patient healthcare. Personal agents enable finding solutions to patient healthcare challenges such as matching a treatment option to a known disease. But individual patients cannot replace doctors, because only doctors can solve and manage patient pathologies.

For *physicians*, the challenge is to find ways to harness the recent advanced technologies to solve real patient problems. Physicians need to apply digital tools to solve diagnostics and therapeutics problems. AI enabled digital twins modeling empowers physicians to identify personalized disease solutions.

AI can help physicians and researchers automate, personalize, consolidate and simplify healthcare processes that will add tremendous value.

"Gemini" means "twins" [or "the twins"] which refers to a critical tool of "digital twins." Digital twins in healthcare provides models for patient wellness solutions, supplies physicians with diagnostics and therapeutics solutions and enables the tracking of diseases and treatment options. AI empowers digital twins and healthcare modeling and analytics. [NASA's Gemini space program refers to a rocket fit for two.]

Gemini's goal is to provide customer solutions by featuring a digital health platform that includes a technological toolkit of SaaS, digital twins modeling, physician health assistants, patient relationship management and patient data security which collectively supply the glue that stiches together a compelling healthcare experience for patients and physicians. Taken together, these technologies have the opportunity to revolutionize medicine.

Gemini's high-barrier "blue ocean" strategy wins customers in a nascent high-growth market.

The AI Revolution and Healthcare Solutions

At least 30% of all labor will be replaced by AI by 2040. McKinsey Global Institute claims that automation threatens 800M jobs by 2030, with as many as 39-73M jobs in the U.S. vulnerable to automation. Kai-Fu Lee, an American-educated Chinese venture capitalist (who funded 10 AI unicorns) has predicted that 40% of all jobs will be lost to AI and robots by 2035.

The most significant industrial development of the last 500 years – the most substantial economic transformation since industrialization – may be imminent. This industrial revolution will cause displacement of labor resources and ultimately lead, according to McKinsey, to a two-tier economy.

In summary, the AI revolution may be the greatest market opportunity ever presented to investors. As an example of this epic investment opportunity, Masayoshi Son, Softbank's CEO and leader of the $100B Vision Fund, is "devoting 97% of [his] time and brain" to AI, with AI the focal point of all his investments. Goldman Sachs predicts GenAI may lift global GDP 7%. The AI revolution is also seen as an epic competition between the U.S. and China. So far, the U.S. is just awakening, with China still outspending the U.S.

AI comprises many tools and techniques, from deep learning to machine learning and GenAI.

While advanced information technologies are progressing rapidly, the healthcare industry is relatively slow to accept these new technologies. Who doesn't have stories about the use of fax machines by physicians or slow health insurance responses to real clinical needs? The healthcare industry can be frustrating particularly because it is slow to adopt useful automation and management technologies.

Gemini's founder, Neal Solomon, has been involved in AI research for over twenty years. His research in intelligent systems has applied AI to network, database, semiconductor and healthcare technology challenges. He holds scores of patents and much of his work involves applications of AI. He holds (thesis length) pioneer AI patents involving hybrid genetic algorithms and a multilayer artificial immune system.

The application of AI to the healthcare industry is relatively new. While there are a number of AI applications to healthcare, the most prominent involve drug discovery, bioinformatics, imaging analysis, clinical drug trials and biomedical analytics. Yet, there is a broad range of AI

healthcare applications that provide fertile ground. In healthcare fields that require automation, personalization and prediction, for example, AI will have substantial applications.

The recent trend of applying generative AI provides a subset of technologies with numerous applications to healthcare. The potential exists for GenAI – which trains and tunes LLMs – to empower intelligent agents that coach physicians as well as to provide assistance in analyzing complex biological models.

The ultimate goal of AI research is development of artificial general intelligence (AGI), which strives to develop a sort of autonomous (sentient) intelligent agent. Open AI, which received a $10B investment, is seeking $100B to develop AGI. AGI is the next step in AI research, but may be out of reach for a generation.

In the context of the AI technology explosion, AI can be applied to maximize digital healthcare system efficiencies. AI can be applied to *healthcare apps* in order to make them both more efficient and more personalized. AI can be applied to software programs in order to consolidate healthcare platform analytical tools. AI can be applied to *modeling* software, including cloud-based modeling and simulation software, in order to optimize outcomes and solutions. AI can be applied to software agents in order to optimize and customize *intelligent healthcare personal assistants*. AI can also be applied to *collect, secure and integrate healthcare data in the IoT*. Taken together, AI technologies provide the opportunity to maximize automation, efficiency, personalization, management, security and outcomes in healthcare.

Yet, so far, the healthcare industry is mainly applying AI solutions in a patchwork of specialties which are generally far removed from patients and physicians.

Gemini is founded to help solve these healthcare challenges by applying AI to several interconnected areas that add great value to customers. Precisely by automating healthcare processes, supplying personalization and solving important healthcare problems, AI is well suited to these applications.

Gemini's goal is to apply advanced technologies for intelligent patient-centered healthcare.

Gemini's Digital Twins System Architecture

Diagnostics: Levels 1-6

Level 1 [General Patient Model]

Level 2 [Bioinformatics Analysis]

Level 3 [Molecular and Cellular Description]

Level 4 [Structural Genetic Combination Pathology Identification]

Level 5 [Functional Molecular and Cellular Pathology Diagnosis]

Level 6 [Diagnostic Prognosis Simulation]

Therapeutics: Levels 7-10

Level 7 [General Therapy Solutions]

Level 8 [Unique Therapy Solution Genesis]

Level 9 [Therapy Option Testing and Simulations]

Level 10 [Therapy Prediction Scenarios]

Level 11 [Unified Patient Model]

Level 12 [Human Population Model]

Diagnostics: Levels 1-6

Level 1

Combine general patent health data into a single package. This may include a patient's genomic data, biomarker data, blood test results, medical digital imaging data and medical IoT device data. For the most part, this initial level captures and collects data for a patient medical DT.

This level is primarily anatomical, like a digital map. This *general* patient model can be accessed and controlled by the patient. As the patient moves between doctors, this general medical information presents an accurate picture of the patient. When a patient gets sick this general model presents a baseline.

In one embodiment of a Level 1 DT, a patient chart informs the patient's DT. Patient form data can be transferred to the DT. Autonomous agents can assist the patient to complete a form, the data from which is then transferred to the DT. Alternatively, a nurse or administrative assistant can work with the patient or physician in order to complete information in the DT.

In some ways, this first level is for general DT modeling, which collects and presents patient data.

This first layer is also applied to maintaining general patient wellness. This basic layer enables patients and physicians to track patient history.

Level 2

This DT level provides a deeper bioinformatics analysis of the patient medical data and provides a report of specific patient maladies over time. A physician can interrogate this model to ascertain general information about a known patient condition. This level of DT provides a physiological evaluation of a patient and provides a summary of their medical records.

Level 3

Building on the previous levels, this DT level provides a detailed view of a patient's cellular and molecular data. This level provides insight into anatomy and physiology of a known patient pathology on a cellular and molecular level.

Level 4

This DT level builds models in order to provide a diagnosis of a unique patient pathology. This level will include the three prior levels. Physicians can interrogate the model in order to identify a specific patient condition that was unknown before. The physician can run tests to verify the condition. A physician can request a second opinion from diagnostic analyses at this level.

Level 5

This DT level is designed to ascertain a patient diagnosis of a specific pathology on a molecular or cellular level. This level also identifies molecular and cellular pathways in order to trace the mechanism of a disease. Since many genetic or hereditary conditions are based identifying a unique set of aberrant genes or dysfunctional proteins, this level is useful for clarifying these genetic sources of a patient disease.

Level 6

This level is designed to identify prognosis of specific disease pathways. The DT presents simulations in order to supply scenarios of possible disease progression based on various inputs. The DT is able to predict various scenarios of behaviors in its animations.

Therapeutics: Levels 7-10

Level 7

This DT level applies methods to identify therapeutic solution options to a particular patient disease on a *general* level. Once a general diagnosis is made, this DT level enables physicians to select a therapy based on similar common diseases. This level is also used to perform tests to ascertain a therapy's probabilities of success. Pharmacogenomics (PGx) is the study of how genome variations dictate a person's response to medications. DTs and AI are applied to PGx by providing simulations of drug interactions in order to assess medicinal outcomes as applied to specific targeted diseases.

Level 8

This level enables physicians to design unique therapeutic solution options based on the results of a diagnosis of a patient's distinctive combination of genetic mutations. This advanced level can be useful in designing novel drug therapies. *DTs, AI and PGx are applied at this level.* In addition, this level conceives of a treatment as a solution to a multivariate genetic optimization problem. In a sense, the therapeutic solution to a multivariate medical problem requires fine tuning an optimal treatment. A physician can seek a second opinion to therapy options at this level.

Level 9

This level allows physicians to provide animations of advanced therapeutic options. This approach enables physicians to experiment with different therapeutic options in order to test viable therapies. Pharmacogenomics (PGx) is the study of how genome variations dictate a person's response to medications. DTs and AI are applied to PGx in order to assess medicinal outcomes as applied to specific targeted diseases.

Level 10

This level enables physicians to track different patient therapy solutions with feedback. With this level, physicians are able to update their therapy options. This level identifies drug interactions and side effects as well. Pharmacogenomics (PGx) is the study of how genome variations dictate a person's response to medications. DTs and AI are applied to PGx in order to assess medicinal outcomes as applied to specific targeted diseases. This level supplies DT simulations of predictive scenarios of various treatment options, enabling the modeling of prognoses relative to various therapeutic inputs.

Level 11

This level combines the previous levels into an integrated whole. The multiple levels reveal specific dimensions of insight into a specific aspect of the human body. This level views the body as a single comprehensive complete picture in which the individual layers can be disassociated in an analysis searching for an understanding of a complex multi-variate disease.

Level 12

This level combines multiple individual DTs into a single sociological map. This level can isolate unique sets of individual patients in order to identify group diseases. Epidemiological

analyses can be performed on this DT level in order to trace causes and consequences of infectious diseases.

Overall, the different levels of DTs represent different "dimensions" of a single multi-dimensional patient DT that captures different views or aspects of the patient's medical data. The unified patient DT represents a sort of digital map of the patient that represents and consolidates their medical history and present; such a DT will follow them for the rest of their lives. When a health episode occurs, the DT can drill down to the organ, cellular or molecular level in order to identify and solve a particular health disorder. These data are stored in the DT for future reference in order to help solve future problems. The consolidated DT models represent a library of the history of a patient.

AI is applied at each level of the DT scale. AI is applied, for instance, to the process of gathering healthcare data for a patient. AI is also applied to analytics in the context of problem finding in order to develop a precision diagnosis. AI is applied to the problem-solving context of seeking medical therapies. Finally, AI is applied to the prediction context of diagnostic and therapeutic prognoses in order to track a disease.

The differentiation of these DT levels enables Gemini to provide different services to physicians and to patients. In the lowest levels, patients may be able to possess their own general model that is then supplied on demand by physicians with the permission of the patient. This general DT map enables the encapsulation of a patient's biomedical map for constant reference. Healthy patients can maintain this lower level of DT as a comparative model.

On the other hand, the higher levels can require rigorous data analysis and custom drug design that is computationally intensive. Gemini may charge high fees for supercomputer time in order to facilitate these advanced diagnostic and therapeutic analyses.

DT's transcend bioinformatics alone. Genomic data, biomarker data and bioinformatics analytics are useful ingredients for DTs. Taken alone, however, they are necessary but not sufficient for developing personalized medicine models of patient health disorders.

For example, IBM Watson Health (sold in 2022 to Francisco Partners, just before the GAI revolution) is a useful approach to diagnostics, which operates by analyzing big healthcare databases to identify patterns common in various pathologies. This system merely identified an existing treatment protocol to each diagnosis of generic symptoms. These diagnoses were generalized because they lacked access to individual patient data due to privacy concerns. But IBM Watson Health required massive investments to process big healthcare data sets, which resulted in an untenable premium selling price to customers. Finally, IBM Watson Health was not focused, as we are, on personalized medicine solutions.

Personal Health Assistant

Solving patient diseases on the molecular or cellular level is complex. First, we need to be able to "see" what we are doing. This observational component is satisfied by DTs in combination with AI and bioinformatics. But physicians need a way to make these systems and services useful in their everyday practice.

Several ventures have developed autonomous agents, including Imbue, Cognosys, Adept, Graft and Inflection. These products may be useful for us.

The PHA is an AI driven autonomous software agent designed for interaction with physicians. The PHAs operate like a software-based personal assistant to enable collection of patient data and general research information, to assist in analysis of healthcare data, to interact with, develop and optimize DTs for diagnostics and therapeutics. The PHAs are cloud-based SaaS systems that operate like a smart general health aide.

In their simplest manifestation, the PHA helps the doctor to understand, explain and interpret their complex medical research, their patient data and the DT analytics.

In one application, PHAs are an outgrowth of healthcare LLMs and advanced interactive Chatbots. However, precisely because they are Chatbots, which are prone to hallucinations, the physician must perform their own analyses and make their own decisions. Still, the PHA is intended to help the physician or researcher to unify the various components of analyzing a particular patient's personalized diagnosis as well as to assist in development of a personalized therapeutics program.

In one embodiment, PHAs can be used by physician assistants or administrators in order to assist patients or in completing data forms that inform DTs.

Also, PHAs can work with PRM apps in order to assist with patient services.

In one mode, each medical specialist category can customize their PHA to personalize to their own practice. Each specialist can operate the PHA from a unified dashboard. Each doctor or researcher can unify the various Gemini apps by applying the PHA.

By linking the various analytical tools required for personalized medicine, the PHA is an indispensable ally.

Patient Relationship Management

Customer relationship management (CRM) software is a major industry organized on the principle that customer support can be automated.

Patients are often confused about the healthcare journey. When they get sick patients typically go to a doctor for a consult, the doctor assesses the patient's conditions and may order tests. When the patient needs to see a specialist, the journey continues. In the case of complex diseases, the journey becomes a labyrinth. In the majority of cases, the quest for a diagnosis is daunting enough. But the application of a complex therapeutic regime is particularly problematic for patients. How are they supposed to get the correct medicines and continue to manage their disease(s)?

PRM is intended to fill in the gaps of the medical system by working with patients and doctors to set up doctor visits, medical testing appointments, pharmaceutical requests and patient tracking. PRM is a sort of after-doctor automation service that fills this critical need.

While PRM can be similar to CRM for most generic healthcare challenges, PRM is essential in the case of personalized medicine. Particularly in those cases in which the medical system needs to be customized for patient care, PRM is optimally suited to track the elements of patient diagnosis and therapeutics. In some cases, a therapy is custom designed to specifically treat a unique medical condition, which must be tracked by PRM. Therapy management requires feedback of the specific therapy options, which feedback and interactions are tracked by the PRM. The patient data are tracked by the patient's internist and team of physicians.

PRM are powered by AI and autonomous agents. The PHA will work with the PRM in order to perform services that assist in satisfying patient needs.

The PRM, which is provided in the cloud as a SaaS, helps to unify the healthcare process to optimize patient medical management.

Patient Data Security

Patient privacy is an important element of the healthcare system. Hipaa requires specific communications constraints in order to promote patient privacy. In order to do so, patients are required to provide permission to enable their information to be private at various junctions in the medical discovery and treatment process.

PDS provides a cloud-based SaaS system that provides encryption for all patient data and patient communications. While Hipaa is about three decades old, founded at a time when fax machines were in their prime, in some ways Hipaa is obsolete. Nevertheless, the impulse to maintain patient privacy is important.

PDS requires patients to provide their assent to the communication of data, such as blood or genetic tests, to physicians. Doctors are required to seek patient permission in order to perform patient data analysis.

De-identification of patient specific data in training data is required a well.

PDS uses encryption software as well as security software agents that are tuned to a patient's needs.

Because generic patient data are required for some big data bioinformatics analytics, there may be a need for a two-tier system in which some patient data is anonymized for big data analyses while other, more specific, data are privatized within the physician's models.

AI, including GAI and ML, are applied to the PDS to as to optimize patient healthcare data security.

PDS is integrated into the various software applications, including the DTs, the PHAs and the PRMs.

Partnership Referral Services

Partnerships with various specialists will be an important component of Gemini. These PRS referrals occur in several categories. We aim to receive a modest referral fee for each referral.

Computational modeling: Physicians and researchers will require supplemental supercomputer modeling (and data storage) services from our data center partners.

Pharmacy referrals: Gemini may refer physicians to pharmacies, particularly for specialized medicines or therapies.

Specialist physician referrals: Once our customers identify a diagnosis, they may require a referral to a specialist that we can facilitate.

Genomic and biomarker testing: We will apply specific genomic and biomarker testing by working with partners.

Biotech and pharma referrals: In some case, physicians may require direct referrals to biotech companies or pharma companies for solutions to patient diseases.

Gemini ties together all of these software applications into a unified whole in its SaaS platform. The integrated software tools embodied in Gemini's system enables physicians and researchers to provide novel personalized diagnostics and therapeutics in order to optimize medical

care. Taken together, these tools simplify and democratize the healthcare system to enable physicians to identify and solve complex medical challenges.

Gemini aims to be the first point of departure for individual healthcare. Initially, the patient will begin with an internist or general practitioner (GP). The GP will work with the digital twins modeling program to diagnose the patient's illness. However, in some cases, the GP will need to provide a referral to one of a number of specialists. In one mode, the Gemini's system will quickly identify a disease and request to move directly to a specialist referral. In any event, Gemini's toolkit of DT modeling, PHA's, PRM and patient security supplies the software services for patient disease diagnoses and therapeutics.

The advantages of this system are that by applying AI at different stages of the healthcare process, patients receive personalized medical evaluation and treatment and physicians receive substantial patient health data in order to develop precise diagnoses and treatment recommendations. The process is rapid, efficient, cost-effective and accurate. The system learns about each patient and stores personalized data in order to optimize each patient's healthcare. Ultimately, the technologies enable doctors to make predictions.

Specific levels of services are charged different fees. For instance, the most intensive use of digital twins modeling for therapeutics may involve individualized disease management solutions that require intensive personalization, effectively generating a novel proteomic cure to a complex genetic disease. These complex simulations may require modeling experiments and interactive modeling on Gemini's platform that will involve intensive computing capabilities.

There are numerous specialist physicians that are targeted, including, but not limited to, the fields of cardiology, oncology, endocrinology, pulmonary, infectious diseases, neurology,

gastroenterology, gynecology, obstetrics, urology, rheumatology, orthopedics, emergency medicine, allergists, immunology, gerontology and pediatrics.

Gemini applies several critical elements of AI. These include automation, personalization, problem solving and prediction. The automation involves stitching together the system, empowering the autonomous agents to perform healthcare functions, supplying power for patient relationship management software and for security services. Personalization is applied to DTs, to autonomous agents and to patient relationship management software and to security. Problem solving and analytics are applied to DTs and to autonomous agents. Prediction is applied to autonomous agents, patient relationship management software and security software. Each of these AI elements are supplied to physicians (for a fee) according to the functional intensity that is requested.

Gemini will eventually develop its own technologies in order to provide novel digital healthcare solutions. Among other things, we intend to develop our own patent portfolio, which will provide us with a legal shield that will promote our competitive advantages.

Gemini's integrated digital health platform consolidates cloud-based software, apps, AI, databases and modeling into a seamless whole. Gemini's technologies optimize patient health and provide solutions to complex disease challenges. By targeting the patient disease life cycle, we provide value at each step in the spectrum of a patient's healthcare.

While the technologies that Gemini harnesses may appear to be simple, they are actually quite complex. Consequently, our entry barriers are very high. Many digital health companies merely apply off the shelf technologies to target markets featuring low hanging fruit. Our target markets are far more essential to human healthcare, with our solutions much more useful

and cost-effective for customers. The quality of our services and the value – not just in time savings, but in customization of solutions and cost savings – provided to customers are incalculable. Our digital technologies embody our competitive advantage. Because these IT and biomedical technologies require interdisciplinary expertise, Gemini enjoys a high barrier to entry.

Finally, Gemini optimizes our product-market fit by supplying a differentiation of qualities of services to physician and researcher customers so they can tailor the technologies to their own practice needs and build up services as they become increasingly comfortable with the technologies. For instance, physicians can personalize PHA autonomous agents to their practice specialty, customize security settings and tune the PRM software to their personal requirements. Doctors can add services on demand.