Expanding Precision Medicine with AI-Powered Integrated Decision Support

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From disease- to health management through data integration

**Reactive**
- Chronic Disease End-of-Life Care
- Chronic Disease Progression
- Chronic Disease Early Stage

**Preventive**
- Sensors & devices
- In-vitro & in-vivo data
- Family / Social data
- Genomics
- Cohort data / phenotyping

**Acceleration of Digital Technology**

**Digital dimension**
- Personalized data model

**Value**
- High Risk
- At Risk
- Lowest Risk
- Health management

**Cost**
- Chronic Disease End-of-Life Care
- Chronic Disease Progression
- Chronic Disease Early Stage
The transformation from digital data to actionable insights

- **Generate data**: Enable digital processing
- **Aggregate data**: Enable utilization of available information
- **Analyse data**: Transfer data into knowledge
- **Operationalize data**: Utilize knowledge to take actions for better care
Generating meaningful insights from disparate data at the point of decision making

**Diagnostic accuracy**

- 25% of patients said their health care provider has **had to re-order tests** to have accurate information for diagnosis\(^1\)

**Data integration**

- 50% of patients report that **information necessary to their care was not available when needed**\(^1\)

**Diagnostic precision through quantification**

- Cognitive factors (perception, failed heuristics) contribute to the diagnostic error in **74%** of cases\(^2\)

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\(^1\) Best care at lower cost: the path to continuously learning healthcare in America, Institute of medicine

\(^2\) Cognitive and System Factors Contributing to Diagnostic Errors in Radiology American Journal of Roentgenology, 201, September 2013
Computed Tomography at Siemens Healthineers
40+ years of Innovation

Data courtesy of Israelitisches Krankenhaus, Hamburg, Germany
Cinematic Rendering: Research use only. Not for clinical use
Diagnostic Imaging can give functional insights

Data courtesy of CUBRIC, UK
Cinematic Rendering: Research use only. Not for clinical use
Precision Medicine

Personalize when it Matters
Reduce Unwarranted Variations

Patient history
Laboratory
Pathology
Imaging

Staff
Modality
Site
Situation
Integrated diagnostics for precise diagnosis confirmation and personalized treatment decision

Historical patient data from EMR

Combining in-vivo and in-vitro biomarkers incl. genomics data

Real-time correlation to reference data and population cohorts

Personalized diagnostics and treatment decision
Integrated decision support through information integration

- INTELLIGENT Information Representation
- CONFIRMATION Right Diagnosis
- DECISION Right Therapy
- IMPROVE Measure KPIs Time, Cost, Quality

Integrated Decisions
Siemens Healthineers Digital Ecosystem -
A community where digital and social assets interconnect and interact
Siemens Healthineers Digital Ecosystem - Members contributing data & knowledge

>4.4k
Clinical collaborations

>3.0k
Providers connected to Siemens Healthineers cloud

~30k
Users of web-enabled technical service

>330k
Sessions of digital training platform

1) Teamplay: April 2018
2) LifeNet: October 2017
3) PEPconnect: FY 2017
Siemens Healthineers Digital Ecosystem - Data benefiting members with actionable insights

>35m + >12m
Usage + dose studies (imaging data)\(^1,2\)

250m
Curated clinical images\(^3\)

10-15k / year
POC results data per hospital\(^4\)

~5GB
Genomic data (patient raw data)\(^4\)

1) Since January 2016 until April 2018
2) Dose studies typically overlap with Usage studies, there is a small number of dose report only studies (not counted in Usage studies)
3) Data from February 2018
We are building our AI capabilities systematically from the ground up

**Scope of data integration**

**Patient Cohort**
- Population health management
- Outcome analysis, quality care, meaningful use

**Patient Centric**
- Predict, plan, prescribe
- Clinical decision support/Digital Twin

**Reading/Reporting Post-Processing/Guidance**
- Measure and quantify
- Detect, diagnose and guide

**Scanner/Instrument Technology**
- Workflow automation
- Reconstruction, advanced physics

**Data examples**

**Comprehensive health data**
(EMR level and beyond) across patients and care settings

**Clinical ("omics"), behavioral, functional, social data**
(integrated for a single patient)

**Images, test results**
from single sample/study
**Multiple studies/sources**
(e.g., multi-modality views/fusion)

**Scanner/instrument control**
(parameters, protocols, positioning, etc.)

**Enabling large scale data aggregation, analytics and prediction**

**Embedded AI, enabling quantification and automation**
Availability of Data and Digital Infrastructure hold great potential to solve challenges with Artificial Intelligence.

Emergence of AI unveils the benefits of training with Big Data.

![Graph showing classification error vs. training data sets for Traditional Machine Learning and Deep Learning/AI. The graph indicates a significant decrease in classification error with increasing training data sets.](image-url)
Powerful platform combined with long-term experience for Artificial Intelligence

- 600,000 imaging, laboratory and point-of-care systems
- 300,000,000 curated images, reports, operational data
- 209,000 patients every hour
- Close clinical collaborations
- Dedicated annotation team
- Regional supercomputing data centers
- 400 patents and patent applications in machine learning
- More than 30 AI-enriched offerings on the market
- 100 in deep learning

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Applying traditional machine learning and deep learning to Radiology Workflow

AI powered Acquisition & Examination
- Accurate patient positioning
- Spine and rib unfolding

AI powered Processing & Interpretation
- ALPHA Anatomical Ranges
- Anatomy Visualiser

AI powered Guidance & Workflow
- Cardiovascular TAVI-Planning
- True fusion
AI helps to reduce unwarranted variations with accurate patient positioning

In 95% of all patients, isocentering could be improved.

More accurate

About 2.6 cm mean deviation

No inter-user variability

Deep learning algorithms help to care for patients more individually

Input
- Color Image Data
- 3D Depth Image Data
- Infrared Image Data

AI
Based on deep learning algorithms, the following are possible:

- Landmark detection
- Range detection based on protocol input
- Range adaption to user changes over time
- Isocenter positioning
- Patient direction analysis

Output
- Right dose modulation with FAST Isocentering
- Right scan direction with FAST Direction
- Correct and complete body region with FAST Range

The system is pending 510(k) clearance, and is not yet available in the United States.
AI helps increased precision with time savings & providing reliable results independent from user skills

No inter-observer variability

Potential for time savings

Less than 1 minute exam-time variation\(^1\)
Save up to $14K per tech and year in workforce overtime salary\(^2\)

\(^1\)Zhongshang Hospital Fudan University, Fudan, CN, Abdomen Dot Engine Workflow Study;
\(^2\)Calculation based on: 38h/week; 48 working weeks/year; average annual salary $70K equals ~$40/h
AI based image analytics can drive automation – AutoAlign enables standardized image results

Standardized planning
Easy and accurate slice positioning without operator intervention - can be applied in many anatomic areas (e.g. Liver, Heart, MSK)

Improved clinical workflow
Allows better patient throughput by reducing possible errors in planning

Reproducibility and robustness
Standardization of image quality from patient to patient. Allows accurate follow-up scans
Radiology is characterized by high volumes of examinations at low reimbursement

35 Million chest procedures per year
87% X-ray
12% CT
1% Nuclear, MRI, US

High volume

CT: $54-86
X-ray: $7-25

Low reimbursement

Numbers represent Medicare reimbursement only. Calculation based on 2015 Medicare reports.
AI based image analytics can drive automation – helping to read chest imaging faster

**Abnormality highlighting**
Helps avoid missed abnormalities and identify incidental findings.

**Augmented reporting**
Provides standardized, reproducible quantitative reports using automated information extraction from images.

**Image-based biomarker**
Assists with differential diagnosis for lung disease

Image courtesy: https://wiki.cancerimagingarchive.net/display/Public/LIDC-IDRI, LIDC-IDRI-0463
This feature is based on research, and is not commercially available. Due to regulatory reasons its future availability cannot be guaranteed.
AI may help increase precision and reduce variability in prostate cancer risk assessment

Conventional TRUS biopsy detects only 48% of clinically significant prostate cancers.\(^1\)

Studies show Multiparametric MRI to be a potentially significant improvement.

Low accuracy of prostate cancer risk assessment

High inter-observer variability

Even experienced radiologists achieve only moderate reproducibility in prostate mpMRI evaluation\(^2\)

\(^1\) PROMIS study, Ahmed et al., Lancet 389: 815 (2017)
\(^2\) Rosenkrantz et al., Radiology 280: 793 (2016)
Artificial Intelligence technology assists prostate cancer risk assessment and supports ease of reporting

**Augmented mpMRI reading**
Leverage algorithms trained on expert findings and correlations with pathology

**Augmented reporting**
Pre-populate PI-RADS (Prostate Imaging Reporting and Data System) structured report

**Enable broad access to mpMRI for early detection of clinically significant prostate cancer**
Enable fast, high-quality adoption beyond specialist centers

This feature is based on research, and is not commercially available. Due to regulatory reasons its future availability cannot be guaranteed.
Inline Cardiac MR analysis

Cine CMR exam → A.I. system

- Deep 121
- Auto 4-chamber cardiac function
- Auto view recognition

Trained on ~60,000 expert annotated images

<table>
<thead>
<tr>
<th>Chamber</th>
<th>Performance (DICE)</th>
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<tbody>
<tr>
<td>Left ventricle</td>
<td>0.93</td>
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<tr>
<td>Right ventricle</td>
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</tr>
<tr>
<td>Left atrium</td>
<td>0.93</td>
</tr>
<tr>
<td>Right atrium</td>
<td>0.95</td>
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</tbody>
</table>

My Cardiac Exam

AI algorithm computes 193 measurements, regional and global

LV, RV (short-axis), LV, RA and LA (long-axis)

LV radial and circumferential strain

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TransEsophageal Echocardiography
Volume TEE, Real-Time 3D Doppler, 3D+t Valve Analysis

S. Grbic, et al., Personalized Mitral Valve Closure Computation and Uncertainty Analysis from 3D Echocardiography, Medical Image Analysis, 2016

Data Courtesy of Piedmont Heart Institute, Atlanta GA
Towards a personalized data model

Digital twin –
life-long, personalized
physiological model
updated with each
scan, exam

Patient-centric,
holistic
treatment

Comaniciu et al, Shaping the Future through Innovations:
From Medical Imaging to Precision Medicine, Medical Image Analysis, 2016.
AI helps building digital twin of a heart
CMRI and EP info fed into twin builder, trained with synthetic data

Digital twin of colleagues heart
Shape, kinematics, stress and strain

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Our Ambition – Digitalizing Healthcare
Enabled by Artificial Intelligence

Expanding precision medicine
- AI drives quality of care
  - Increasing reliability of measurements
  - Reducing unwarranted variations

Transforming care delivery
- AI drives efficiency and productivity
  - Enabling increased workforce productivity through automation
  - Optimizing clinical operations

Improving patient experience
- AI drives outcomes that matter to patients
  - Prioritizing complex/acute cases
  - Avoiding unnecessary interventions

Digitalizing healthcare
Thank you

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