RSNA Radiological Society of North America

ACR American College of Radiology

AAPM American Association of Physicists in Medicine

MIDRC Medical Imaging and Data Resource Center

Joint Council Session – AAPM 2021
Creativity in Medical Physics

Extending AAPM Leadership to Advance Data Science in the Age of COVID-19

Maryellen Giger, Ph.D.
University of Chicago

NIH National Institute of Biomedical Imaging and Bioengineering

The University of Chicago

Extending AAPM Leadership to Advance Data Science in the Age of COVID-19

Abstract:

- **MIDRC** represents an NIBIB-funded partnership spearheaded by the medical imaging community and aimed at building data repositories to fuel COVID-19 machine intelligence research, coupled with optimal standardization, curation, and compliance with ethical responsibilities to honor patients' privacy.
- This **partnership** will lead to development and implementation of new diagnostics, including machine learning algorithms, that will empower population-wide preventive and management strategies for COVID-19.
- This **leadership collaboration** among the ACR, RSNA, and AAPM is based on each organization's unique and complementary expertise within the medical imaging community, with **AAPM bringing its expertise** in
  - physical image quality/harmonization and
  - tailored distribution/metrology standards/evaluation metrics.

Creativity in Medical Physics
Extending AAPM Leadership to Advance Data Science in the Age of COVID-19

- AAPM plays a major role
- In a sense, AAPM's participation was "years in the building" involving many **AAPM Science Council members** and many committees, subcommittees, and other groups
- Let's expand on that last sentence in the abstract:
  - This leadership collaboration among the ACR, RSNA, and AAPM is based on each organization's unique and complementary expertise within the medical imaging community, **with AAPM bringing its expertise in**
    - **physical image quality/harmonization and**
    - **tailored distribution/metrology standards/evaluation metrics**.

physical image quality/harmonization

&

tailored distribution, metrology, standards, evaluation metrics

AAPM Science Council: Examines specific areas of medical physics to determine advancement mechanisms, addresses scientific questions, and collates and assesses data.

SC Imaging Physics Committee: The IPC is a committee of the Science Council and has direct authority and responsibility over all AAPM scientific activities pertaining to diagnostic medical imaging.

SC Therapy Physics Committee: The TPC is a committee of the Science Council and has direct authority and responsibility over all AAPM scientific activities pertaining to radiation therapy physics.

SC Research Committee : The RSRCH is a committee of Science Council and oversees opportunities and funding for research activities of medical physicists. Members have a long history of participation in QIBA.

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The Foundation

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SC Technology Assessment Committee: TAC is a committee of the Science Council and is responsible for technology assessment efforts of the AAPM, including assessments of imaging and therapy technologies, and other activities that enhance the research potential and quality assessment capabilities of medical physicists.

SC Data Science Committee: DSC (previously called BRM) is a committee of the Science Council and aims to coordinate, steer and organize AAPM efforts in the fields of Big Data, Radiomics, Machine Learning, and related areas.

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Initiated in 2009

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Initiated in 2018

Technology Assessment Committee (TAC)

- The Technology Assessment Committee is responsible for technology assessment efforts of the AAPM, including assessments of imaging and therapy technologies, and other activities that enhance the research potential and quality assessment capabilities of medical physicists.
- In 2008, as President-elect, Giger met with each of the three Councils – Science Council, Education Council, and Professional Council to understand their needs for her next year as President of AAPM
  - Science Council mentioned the need for technology assessment and also, throughout the nation there was much talk on clinical effectiveness, of which technology assessment was a part.
- Ad hoc on the Establishment of a Technology Assessment Institute
  - 2009 Bill Hendee as chair
- Became the SC Technology Assessment Committee (TAC)
  - 2011-2013 Bill Hendee
  - 2014-2017 Maryellen Giger
  - 2018-present John Hazle
- Submitted Grants: 2009, 2013

Data Sciences Committee (DSC)

- The DSC aims to coordinate, steer and organize AAPM efforts in the fields of Big Data, Radiomics, Machine Learning, and related areas.
- In 2018, as President-elect, Cynthia McCollough also met with each of the three Councils – Science Council, Education Council, and Professional Council to understand their needs for her next year as President of AAPM. Data Science was a major topic.
- **DSC was formed under Science Council (initially listed as BRM)**
  - 2018-present led by Maryellen Giger with Joe Deasy, now with Chuck Mayo
  - **Big Data Subcommittee**
    - Chuck Mayo, Kristy Brock
  - **Radiomics Subcommittee**
    - Sam Armato, Stephen Bowen
  - **Machine Learning Subcommittee**
    - Issam El Naqa, Berkman Sahiner
  - **Imaging Metrology and Standards Subcommittee**
    - Paul Kinahan

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Focused recruitment of SC chairs and members to include both therapy and diagnostic medical physicists

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  - **Imaging Metrology and Standards Subcommittee**
    - Paul Kinahan
  - **And now MIDRC Subcommittee**
    - Maryellen Giger and Paul Kinahan

AAPM Data Science Roundtable – March 2019

- Called by AAPM President McCollough
- Asking for all to work together.
- Invitees included representatives (and their talks) from:
  - ACR
  - RSNA
  - ASTRO
  - SIIM
  - ARBIR
  - SPIE
  - NIST
  - NCI CIP and QIN
  - NIBIB
  - FDA

AAPM Data Science Roundtable

- President's welcome & introductions (Cynthia McCollough)
- AAPM's Big data, radiomics, machine learning (BRM) vision (Joe Deasy)
- Research Committee's objectives (Paul Kinahan)

- Presentations from BRM/DSC included
  - Big Data -- Strategy for AAPM (Chuck Mayo)
  - Radiomics -- Strategy for AAPM (Sam Armato)
  - Machine Learning (ML) -- AAPM's role in developing and promoting ML technology (Issam El Naqa)
  - Data Quality and Standards -- AAPM's role in ensuring data quality for BRM (Ed Jackson)

In parallel, at NIBIB led by Bruce Tromberg

Medical Imaging and Data Resource Center
THE ORIGIN

NIBIB convenes medical imaging academics, professional organizations, industry and other Federal agencies with workshops on **AI in Medical Imaging** (August 2018) & **Acceleration of Clinical Applications of Machine Intelligence in MI** (November 2019), which identified critical gaps:

1) Absence of large & diverse medical image datasets
2) Need to integrate siloed databases & knowledgebases
3) Need to develop non-redundant efficient AI tools
4) Need to create an ecosystem of stakeholders to develop clinically validated AI applications that improve patient management and clinical outcomes

Parallel workshops by ARBIR/NIST, RSNA and AAPM in 2018-2019 confirm the developing consensus

Slide courtesy of Kris Kardarpa, NIBIB

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Discussions on an appropriate use case to demonstrate the need and solutions.

Parallel workshops by ARBIR/NIST, RSNA and AAPM in 2018-2019 confirm the developing consensus

Slide courtesy of Kris Kardarpa, NIBIB

Then there was the COVID-19 Pandemic

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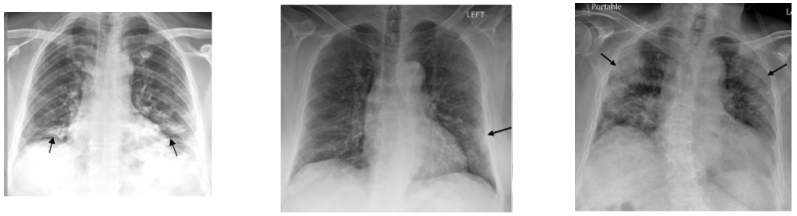
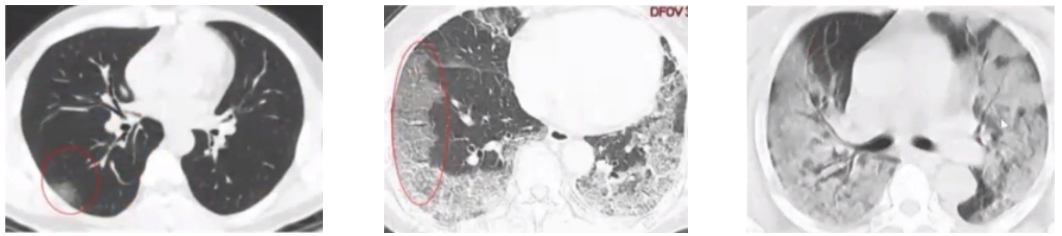
- COVID-19 impacts **lungs, as well as heart, vessels, & brain**.
- Need to **collect medical images** and **develop artificial intelligence** (AI) methods to aid in the analysis / interpretation of medical images



Various presentations of COVID-19 on chest radiographs from three different patients



Early Stage | Progressive Stage | Severe Stage

Various stages of COVID-19 shown on chest CTs from three different patients

Rapid Response to COVID-19 Pandemic

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Established August 21, 2020

University of Chicago NIBIB Contract PI: Maryellen Giger

American Association of Physicists in Medicine (AAPM) PIs:

- Maryellen Giger (University of Chicago & AAPM Data Science Committee Chair)
- Paul Kinahan (University of Washington & AAPM Research Committee Chair)

Radiological Society of North America (RSNA) PIs:

- Curtis Langlotz (Stanford University & RSNA Board Liaison for IT & Annual Meeting)
- Adam Flanders (Thomas Jefferson University & Member RSNA CDE Committee)

American College of Radiology (ACR) PIs:

- Etta Pisano (ACR Chief Research Officer & Harvard University)
- Michael Tilkin (ACR Chief Information Officer)

Gen3 PI: Robert Grossman

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THE UNIVERSITY OF CHICAGO

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- Paul Kinahan (University of Washington & AAPM Research Committee Chair)

Radiological Society of North America (RSNA) PIs:

- Curtis Lang
- Adam Flan

AAPM's participation:
Natural extension of AAPM DSC, TAC, & RSRCH

American College of Radiology (ACR) PIs:

- Etta Pisano (ACR Chief Research Officer & Harvard University)
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Goals

- Progress from data to deployment & hypothesis to discovery
- Accelerate the creation and transfer of knowledge for clinical management of COVID-19

A. Open Discovery Data Repository Commons

B. Machine Intelligence Computational Capabilities

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- MIDRC -- radiologists & medical imaging scientists from across the nation
  - 23 institutions from academia, community practices, FDA
  - Expert collaboration with community engagement
- See website for listing of all investigators
  - **https://www.midrc.org**
- High-quality and diverse data commons enabling researchers to address topics no single archive could yield independently

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Two Data Intake Portals

RSNA
COVID-19 Database
RICORD

ACR
COVID-19 Imaging Research REGISTRY™

One Output User Portal

University of Chicago

- To be accessed by hundreds of researchers and developers of AI.
- For training and testing of AI to reduce bias and enhance diversity.
- To expedite translation of AI to clinical care.

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Two Data Intake Portals

RSNA COVID-19 Databa

RICORD

ACR COVID-19 Imaging Research REGISTRY™

AAPM -- quality assurance and evaluation procedures

One Output User Portal

University of Chicago

GEN3 DATA COMMONS

- To be accessed by hundreds of researchers and developers of AI.
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MIDRC: Technology Development Projects

The **MIDRC infrastructure and processes** will be created through five **Technology Development Projects**, which will be conducted collaboratively:

1. Creating an open discovery platform for COVID-19 imaging and associated data (**led by RSNA**).
2. Creating a real-world testing and implementation platform with direct real-time connections to health care delivery organizations (**led by ACR**).
3. Developing and implementing quality assurance and evaluation procedures for usage across the MIDRC (**led by AAPM**).
4. Enabling data intake, access and distribution via a world-facing data commons portal (**led by all three plus Gen3**).
5. Linking the MIDRC to other clinical and research data registries (**led by all three plus Gen3**).

Three MIDRC Data Science Subcommittees

- DSIT - Data Standards and Information Technology Subcommittee
  - led by RSNA
- DPP - Data Policy and Procedures Subcommittee
  - led by ACR
- DQH - Data Quality and Harmonization Subcommittee
  - led by AAPM

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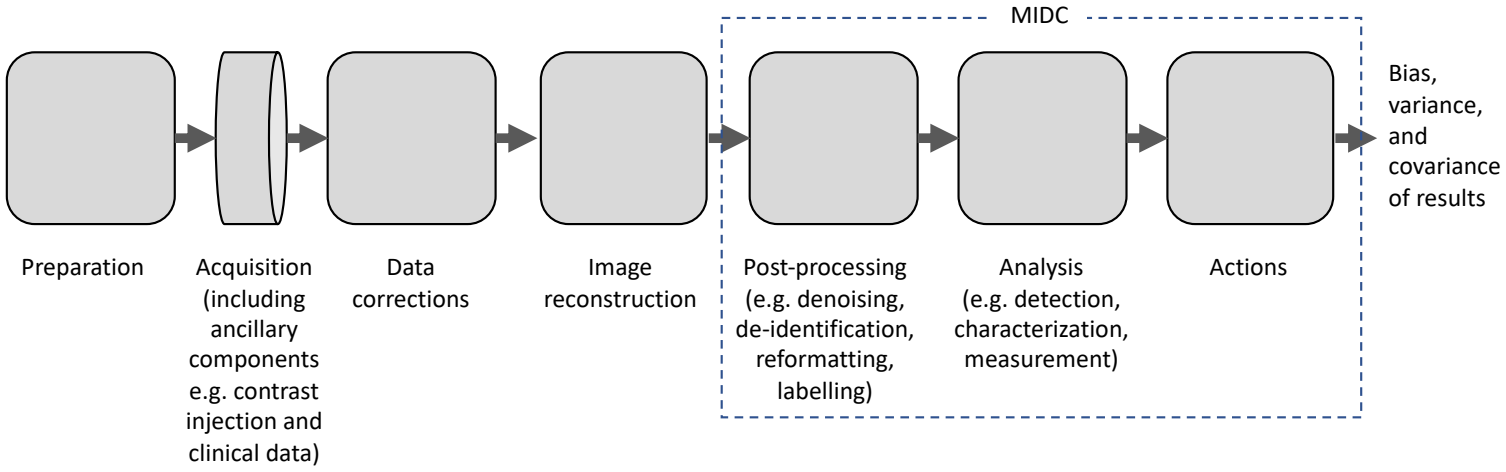
TDP 3: Developing and implementing quality assurance and evaluation procedures for usage across the MIDRC (led by AAPM).

- TDP 3a: Development of digital and physical imaging phantoms for COVID data
- TDP 3b: Assessment of image quality on ingestion into MIDRC
- TDP 3c: Development of benchmarking methods for the various technology assessment and clinical tasks in COVID-19 research and translation
- TDP 3d: Development of task-based distribution methods

TDP3a: Development of digital and physical imaging phantoms

(John Boone, Paul Kinahan, Tony Siebert, Andrey Fedorov, Nicholas Bevins, Dan Sullivan)

- Evaluation of existing general (ACR) and specific (Corgi) phantoms
- Use of automated image analysis tools
- Developing a digital phantom to assess impact of de-identification methods



TDP3b: Assessment of image quality on ingestion into MIDRC

(Paul Kinahan, John Boone, Tony Siebert, Andrey Fedorov, Nicholas Bevins, Dan Sullivan)

Two main components:

- Assessment of the images themselves where there are manual and semi-automated approaches available to search for and assess known structures and artifacts (e.g. from implants)
- Use of the image meta-data that is stored in the DICOM image
    - An exploratory component is to combine parameters derived from the images with the meta-data to general image quality metrics

Efforts on evaluating image data quality early in the ingestion process are driving the efforts of the Data Quality and Harmonization

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TDP 3c: Development of benchmarking methods for the various technology assessment and clinical tasks in COVID-19 research and translation

(Michael McNitt-Gray, Berkman Sahiner, Karen Drukker, Maryellen Giger)

- Develop useful information and recommendations on performance assessment metrics and analytical approaches that are task-specific; includes identifying analysis resources (research articles, available software packages, etc.).
- Coordinate with TDP3d on how to best use sequestered data to provide reference analyses and benchmark limits for performance metrics
- Coordinate with CRPs to ensure consistent use of performance assessment approaches and metrics.

TDP 3d: Development of task-based distribution methods
(Kyle Myers, Maryellen Giger, Heather Whitney, Natalie Baughan)

1) Develop sequestering algorithm and oversee the sequestering of data separate from public data
2) Develop methods and software for task-based distribution that will be made available via the MIDRC website to MIDRC users and to others so that they can use such methods in their AI development, training, and testing
3) Combine task-based distribution with the sequestered dataset so that MIDRC can independently evaluate AI algorithms for a specific clinical task, claim, and population, which might be used in the regulatory process.

MIDRC: Collaborative Research Projects (CRPs)

- Each of the three lead organizations, **RSNA, ACR, and AAPM, have major data science committees** that are already actively pursuing aspects of big data science in medical imaging and the role of machine intelligence.
  - RSNA has its Radiology Informatics Committee (RIC)
  - ACR has its Data Science Institute (DSI)
  - **AAPM has its Data Science Committee (DSC)**
- Thus, the MIDRC PIs, serving as the initial Executive Advisory Committee, developed the **twelve research projects** to be immediately funded through the MIDRC within the initial contract in order **to expedite the AI research** leading to **rapid translation** to the public and clinical impact.
- The investigators were selected from current members of the RSNA-RIC, ACR-DSI, or AAPM-DSC, thus, effectively **spanning the nation and spanning the medical imaging community**.

Collaborative Research Projects – Investigators through the various Data Science Committees at ACR, RSNA, & AAPM

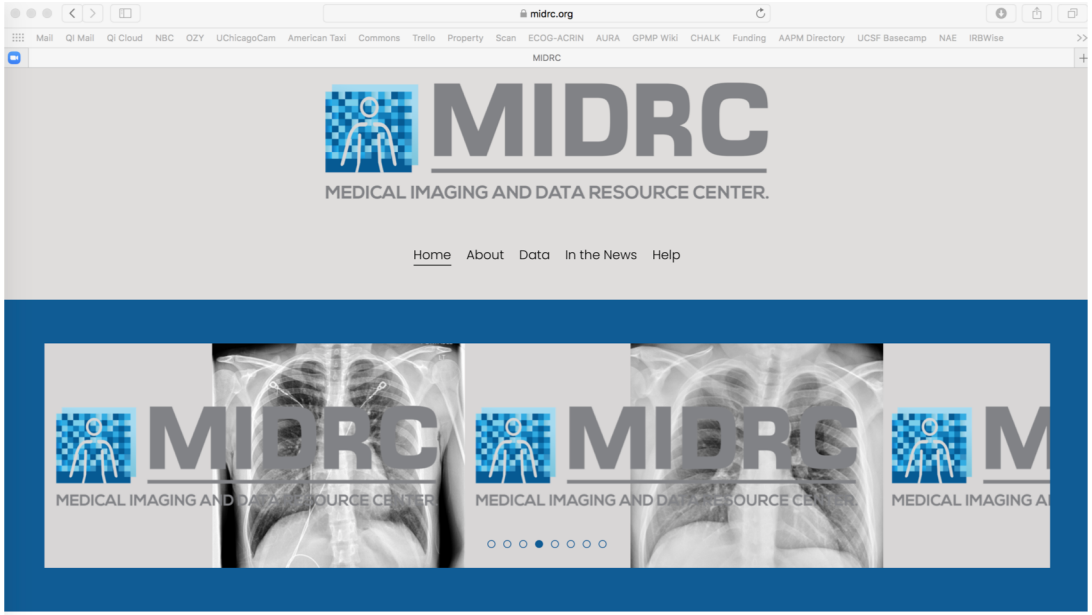
Project	Title
1	Natural Language Processing of Radiology Reports for COVID-19
2	Machine Intelligence Algorithms from Multi-Modal, Multi-institutional COVID-19 Data
3	Image Labeling and Annotation by a Crowd of Experts for COVID-19
4	Efficient Training and Explainability of Machine Learning Methods from Multi-Institutional Data
5	COVID Pneumonia Machine Learning Algorithm Validation and Visualization
6	Safe Public Training Dataset for COVID-19 Machine Learning Algorithms
7	Leveraging Registry Data to Conduct Virtual Clinical Trials
8	Prediction of COVID Pneumonia Outcome using Radiomic Feature Analysis
9	Radiomics & Machine Intelligence of COVID-19 for detection and diagnosis on chest radiographs and thoracic CTs
10	Visualization & Explainability of Machine Intelligence of COVID-19 for prognosis and monitoring therapy
11	Investigation of image-based biomarkers for radiogenomics of COVID-19
12	Determining COVID-19 image data quality, provenance, and harmonization

Trans-MIDRC scientific workgroups

- Grand Challenges Work Group
  - Created to coordinate effort on all aspects of challenges
  - Potential to merge top performing algorithms to benefit the common good
- Bias and Diversity Work Group
  - Goal of assessing and mitigating bias in data and ML
  - Diversity in MIDRC investigators and users

CRPs led by AAPM members

- CRP 9: Radiomics & Machine Intelligence of COVID-19 for detection and diagnosis on chest radiographs and thoracic CTs
  - Sam Armato, Lubomir Hadjiski, Karen Drukker
- CRP 10: Visualization & Explainability of Machine Intelligence of COVID-19 for prognosis and monitoring therapy
  - Maryellen Giger, Hui Li, Issam El-Naqa, Jonathan Fuhrman, Isabelle Hu, Naveena Gorre
- CRP 11: Investigation of image-based biomarkers for radiogenomics of COVID-19
  - Weijie Chen, Sandy Napel, Maryellen Giger, Diane Lauderdale
- CRP 12: Determining COVID-19 image data quality, provenance, and harmonization
  - Paul Kinahan, Andrey Fedorov, Dan Sullivan



midrc.org is for:

- researchers
- data contributors
- the public

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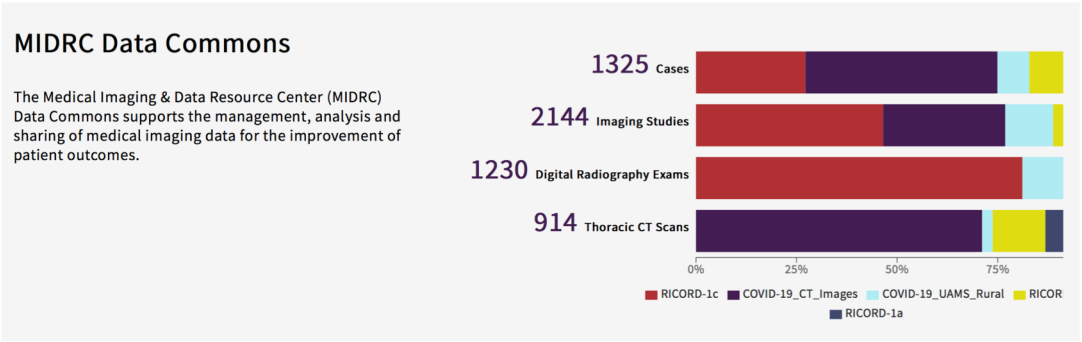
Sign up with your email address to receive news and updates. Please note that subscription is a two-step process: a confirmation email will be sent to the email address provided for you to confirm subscription.

https://www.midrc.org/register-to-receive-newsletter



data.midrc.org
is for searching and downloading data

Summary: MIDRC is more than just a data registry

MIDRC
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- A **high-quality and diverse data commons** led by **major imaging societies** enabling researchers to address topics no single archive could yield independently

Including:

- Proactive, encouraging system for **changing the culture of contributing data for the common good.**
- **User-friendly open output portal** for browsing/exploring the data, creating cohorts, and downloading data.
- **Research on AI development** including algorithms as well as techniques for digital reference phantoms, computer annotating & crowd sourcing for "truth", NLP of radiology reports, and virtual clinical trials.
- **Sequestered data commons** of diverse cases that will be used to independently evaluate AI algorithms for specific claims, clinical tasks, and populations (while retaining the integrity of the test set).
- **Public website** for **dissemination of information** on metrics of evaluation, task-based distribution methods, related software, and white papers such as ones on explainability of AI.
- Mechanism for hosting of **Grand Challenges.**
- **Welcoming scientific community** for collaboration with other societies, institutes, and organizations.

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AAPM co-leads this creative initiative

Thank you

To learn more: Attend
AAPM MIDRC
SAM Imaging Scientific Symposium
Sunday 7/25/2021
SU-CD-TRACK 3