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# UNLOCKING THE POTENTIAL OF NATIONWIDE HEALTH DATA

## SECURE FEDERATED LEARNING WITH NVIDIA FLARE™

FEBRUARY 2023

Juergen Klenk, PhD, Principal, Deloitte Consulting LLP
Jesse Tetreault, MS, Solutions Architect, NVIDIA Corporation

# WHO WE ARE

## DELOITTE'S PUBLIC HEALTH FOOTPRINT

Deloitte has proven experience working with clients across HHS and CDC, state and local public health departments, and the commercial healthcare space to implement AI and analytics solutions aimed at generating insights to improve the health of individuals and communities.

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### WE HAVE A PROVEN TRACK RECORD IN DATA & ANALYTICS

Gartner named Deloitte #1 in Ability to Execute in Data and Analytics Services in 2021.

### WE'RE WORKING TO MODERNIZE CDC'S DATA PIPELINES AS WE SPEAK

We are heavily involved in modernizing and automating CDC's data pipelines from states, hospitals, and public health labs (e.g., Electronic Case Reporting, Electronic Lab Reporting, Advanced Molecular Detection pipelines).

### WE'VE WORKED EXTENSIVELY WITH CDC'S STLT PARTNERS

We work with 48 states, DC, and Puerto Rico including many health departments and have supported or have insight into many outbreak/pandemic data analytics and modeling solutions used in the states.

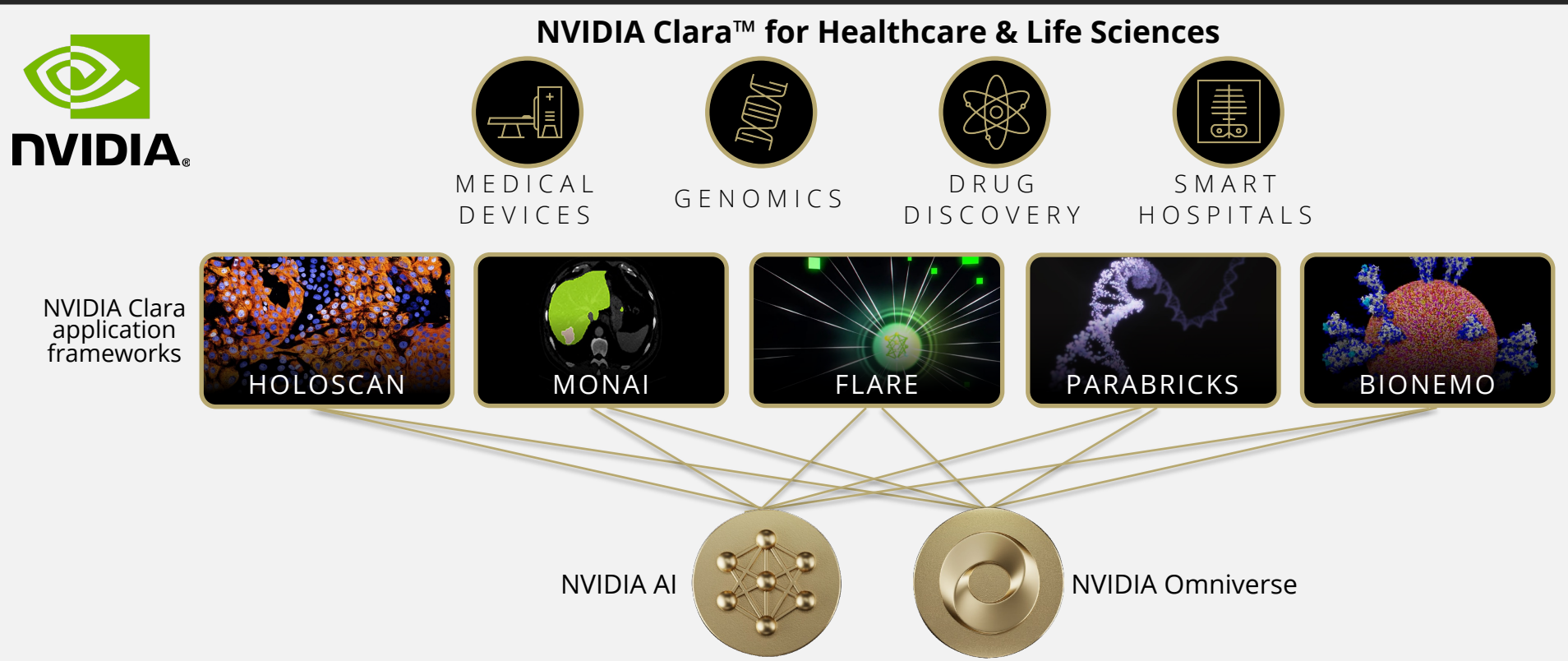
### WE HAVE THE METHODS, TOOLS & PARTNERS TO ACCELERATE INNOVATION

Our AI innovation labs, AI-focused small business acquisitions, and key partners such as NVIDIA enable us to help clients develop cutting-edge AI solutions to address their most difficult challenges.

# WHO WE ARE

## NVIDIA POWERS BREAKTHROUGHS IN HEALTHCARE & LIFE SCIENCES

Public health demands new computing paradigms to enable breakthroughs in data science that will allow for timely and accurate prediction, prevention, and treatment of diseases and health risks. With NVIDIA, CDC can harness the power of artificial intelligence (AI) and high-performance computing (HPC) to define the future of public health.



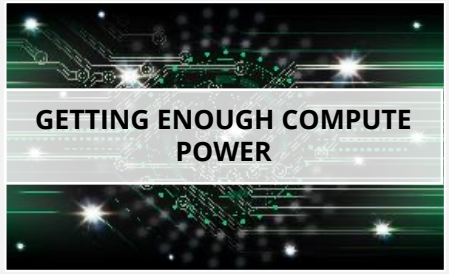
# KEY CHALLENGES FACING CDC

### GETTING BETTER DATA, FASTER

A model's predictions are only as good as the data that the model was trained on. Data CDC receives from both healthcare entities and STLT partners often lacks standardization, requires time-intensive manual cleaning and transformation, and may be limited due to privacy concerns and data use agreements of varying scope.

### MAXIMIZING ACCURACY WHILE PROTECTING PRIVACY

Various universities, federal agencies, and other entities are developing and training similar forecasting models in silos, largely due to privacy issues that inhibit or prevent universities, states, and healthcare providers from sharing data to collaborate on model development.



### GETTING ENOUGH COMPUTE POWER

Training and deploying large, complex models requires access to powerful processors and graphics processing units (GPUs) for training, as well as scalable storage for storing data and model parameters.

### TRANSLATING COMPLEX DATA INTO DECISION-MAKING TOOLS

CDC must be able to translate complex statistical findings into understandable, actionable insights for a wide variety of audiences including both the general public and top decision-making officials.

## THE NATIONAL WEATHER SERVICE DIDN'T HAVE TO DEAL WITH HIPAA.

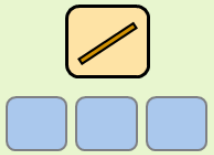
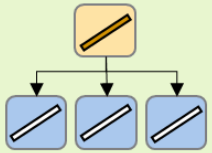
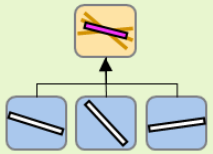
Establishing a National Weather Service (NWS) for infectious diseases and other public health threats is an achievable goal, but we understand that CDC faces additional challenges and complexities inherent in working with healthcare and public health data

# MAXIMIZING ACCURACY WHILE PROTECTING PRIVACY

## Federated learning allows for model training without exchanging data

Federated Learning is a **privacy-preserving** approach to training machine learning models across a decentralized network of data providers. It can enable access to the large amounts of siloed, sensitive training data needed to create high-accuracy predictive models while mitigating the risk of compromising data security and privacy with included privacy-preserving algorithms and workflow strategies.

Federated learning brings the training to the data, sending only the updated model *parameters* back to the central server for incorporation into the global model – with no data transfer required.

| 1. *Initialize Model* | 2. *Broadcast Model* |
|---|---|
|  Orchestrating server creates an initial model using synthetic data or random weights |  The initial model is sent to each data provider |
| **3. *Retrain Model Locally*** | **4. *Aggregate & Update Model*** |
|  Data providers evaluate and retrain the initial model using local datasets that are stored on isolated client machines |  *Only* model weights are sent back to the orchestrating server by clients then are aggregated to create a global model |

## WHERE HAS FEDERATED LEARNING (FL) BEEN USED?

- **Google** and **Apple** use federated learning to train keystroke prediction models across millions of smartphones without collecting user text data
- A consortium of leading pharmaceutical companies participated in **Project MELLODDY** to collaboratively build federated drug discovery models without revealing patient data or commercial secrets

# NVIDIA FLARE™

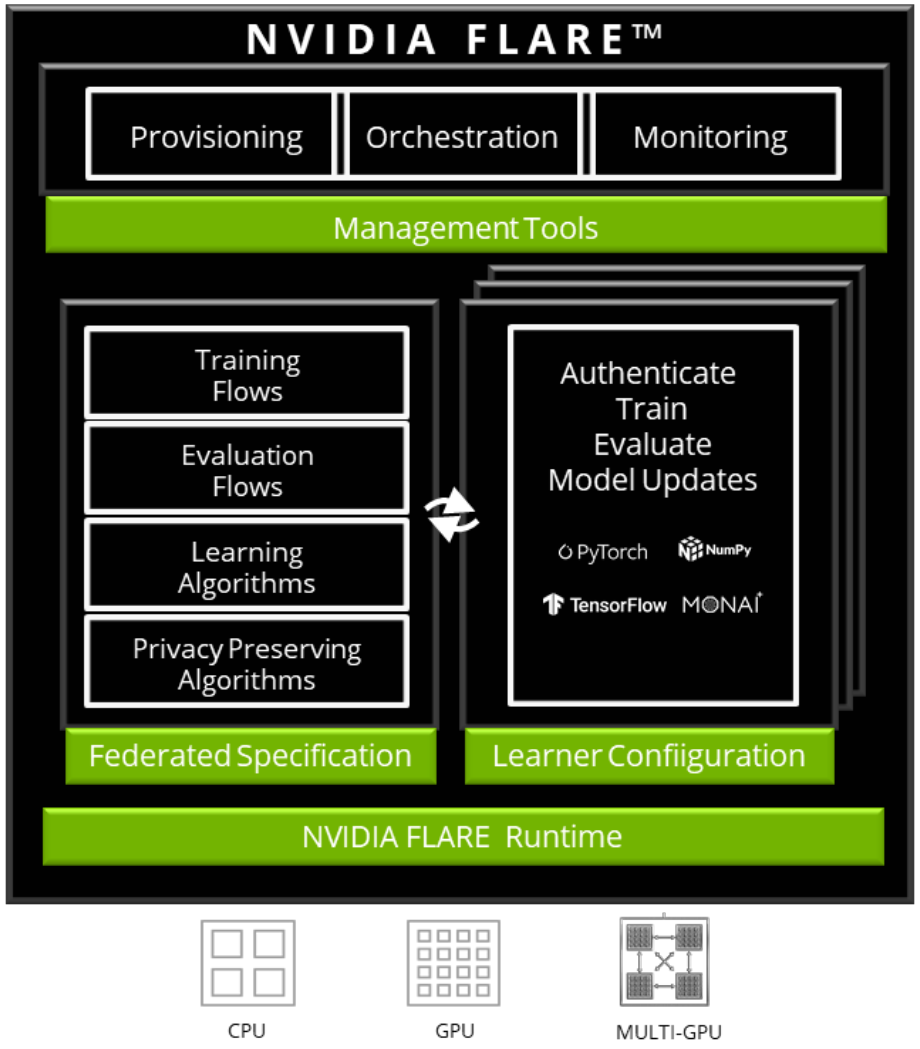
## Open-Source Software Development Kit (SDK) for Federated Learning

NVIDIA FLARE™ (NVIDIA Federated Learning Application Runtime Environment) is a domain-agnostic, open-source, and extensible SDK for federated learning. It allows researchers and data scientists to adapt existing ML/DL workflows to a federated paradigm and enables platform developers to build a secure, privacy-preserving offering for a distributed multi-party collaboration.

## Key Features

- **Open-source, cloud agnostic framework**
- Apache License 2.0 to catalyze FL research & development
- Enables distributed, multi-party collaborative learning
- Production scalability with high availability and multi-task execution
- Enables adaptation of existing ML/DL workflows to a federated paradigm
- Privacy-preserving algorithms
  - Homomorphic encryption & differential privacy
- Secure provisioning, orchestration & monitoring
- Programmable APIs for extensibility

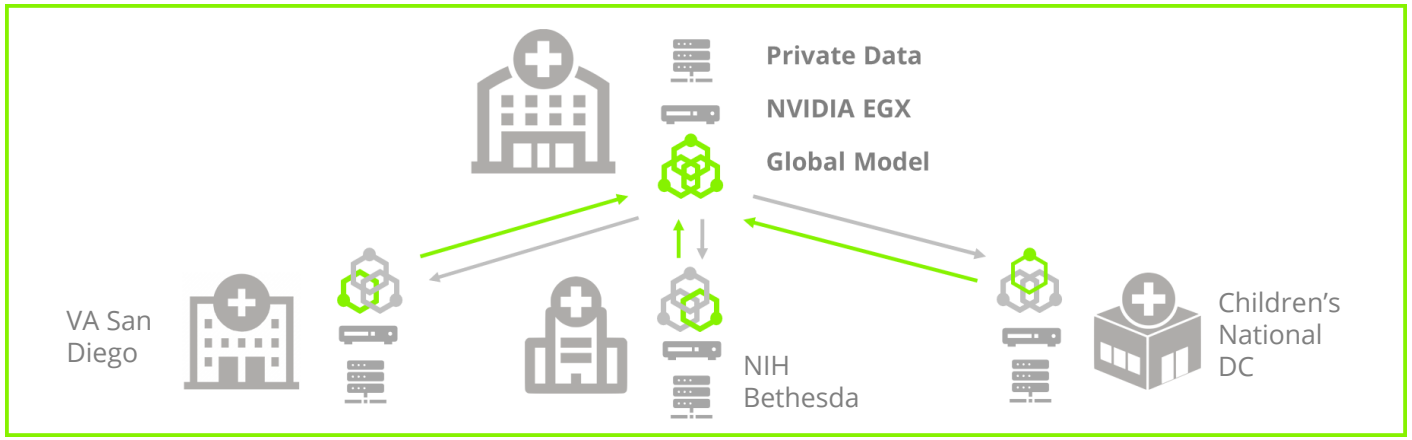
**Available on GitHub: https://github.com/nvidia/nvFlare**



# FEDERATED LEARNING IN ACTION

## CASE STUDY: AN FL MODEL TO PREDICT OXYGEN NEEDS WITH NVIDIA FLARE™

The EXAM (**E**MR C**X**R **A**I **M**odel) study, led by Mass General Brigham and using **NVIDIA FLARE**, brought 20 hospitals across five continents together to train a neural network that predicts the level of supplemental oxygen a patient with COVID-19 symptoms may need.




Note: Sample of participating institutions shown for illustrative purposes

**Model inputs**

Chest X-ray images, vital signs, demographic data, laboratory values

**Model output**

"CORISK" score corresponding to oxygen support requirements

## KEY RESULTS

**0.92** Average area under the curve (AUC) for predicting patient outcomes

**16%** Improvement in AI model average performance across sites compared to single-site training

**38%** Average increase in generalizability across sites compared to single-site training

*"In this study, FL facilitated rapid data science collaboration without data exchange and generated a model that generalized across heterogeneous, unharmonized datasets for prediction of clinical outcomes in patients with COVID-19, setting the stage for the broader use of FL in healthcare."*[1]

1. Dayan, I. et al. Federated learning for predicting clinical outcomes in patients with COVID-19. *Nat. Med.* **27**, 1735–1743 (2021). https://doi.org/10.1038/s41591-021-01506-3

# FEDERATED LEARNING MODEL PERFORMANCE

## PROOF OF CONCEPT: X-RAY IMAGE CLASSIFICATION WITH NVIDIA FLARE™

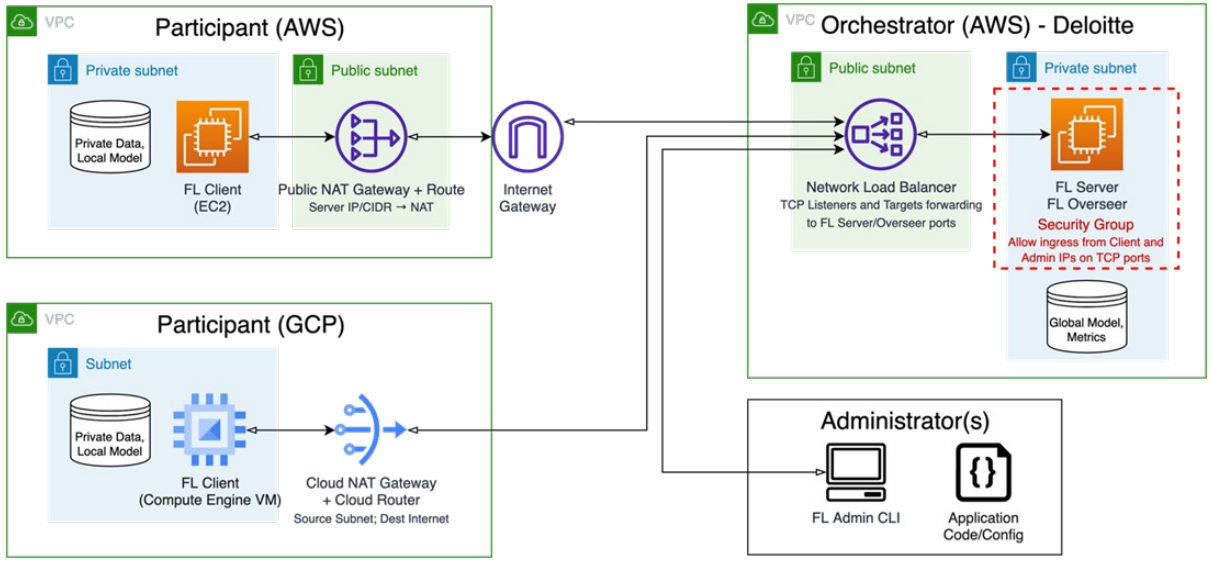
Deloitte's AI Foundry built a proof of concept (POC) to simulate and administer a federated learning system with multiple data providers to train and evaluate a federated deep learning model using decentralized medical image datasets. We then designed a benchmarking study to analyze how well federated learning models perform in comparison to models that are trained on centralized (or siloed) datasets.

**Learning Task**

*Binary classification*: Given a patient's chest X-ray image, predict whether the patient has pneumonia

**Data**

We partitioned the PneumoniaMNIST dataset (approx. 6,000 images) to simulate a setting where image data is held by multiple data providers



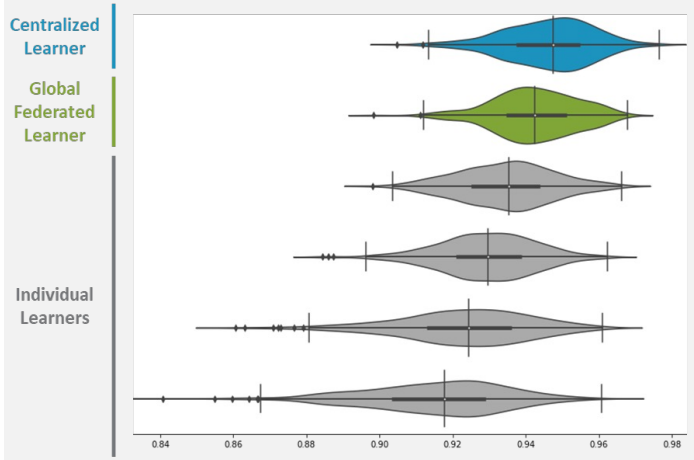

Note that while configuration shown here uses Amazon Web Services (AWS), NVIDIA FLARE can be deployed via any cloud provider, including Microsoft Azure.

## KEY RESULTS

**70%** Percentage of experiments where the FL model's AUC was within 1% of the centrally-trained model's AUC

**35%** Percentage of experiments where individually-trained models' AUCs were within 1% of the FL model's AUC

**ROC-AUC Score Distribution (Violin Plot) from Benchmarking Study**



# FEDERATED LEARNING MODEL PERFORMANCE

## ADDITIONAL EVIDENCE VALIDATING FL MODEL PERFORMANCE

Various research conducted in this space have also demonstrated that FL models perform comparably to models trained on centralized data sets and achieve superior performance when compared to those trained on individual, siloed data sets.

### FEDERATED LEARNING IMPROVES SITE PERFORMANCE IN MULTICENTER DEEP LEARNING WITHOUT DATA SHARING

*Journal of The American Medical Informatics Association*

"The power of federated learning was successfully demonstrated across 3 academic institutions using real clinical prostate imaging data. The federated model demonstrated **improved performance across both held-out test sets from each institution and an external test set**, validating the FL paradigm."[1]

### MULTI-INSTITUTIONAL DEEP LEARNING MODELING WITHOUT SHARING PATIENT DATA: A FEASIBILITY STUDY ON BRAIN TUMOR SEGMENTATION

*International MICCAI Brain Lesion Workshop*

"Our quantitative results demonstrate that the performance of federated semantic segmentation models (Dice=0.852) on multimodal brain scans is similar to that of models trained by sharing data (Dice=0.862). **We compare federated learning with two alternative collaborative learning methods and find that they fail to match the performance of federated learning.**"[2]

### FEDERATED LEARNING IN MEDICINE: FACILITATING MULTI-INSTITUTIONAL COLLABORATIONS WITHOUT SHARING PATIENT DATA

*Scientific Reports*

"Notably, averaging over institutions, the CDS [collaborative data sharing] model performance is 3.17% greater than the single institution models on their own validation data, and **for FL the increase is 2.63%**."[3]

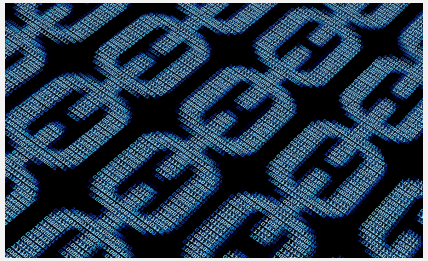
[1] Sarma, K. V. et al. Federated learning improves site performance in multicenter deep learning without data sharing. *J. Am. Med. Inform. Assoc.* **28**, 1259–1264 (2021). https://doi.org/10.1093/jamia/ocaa341

[2] Sheller, M. J., Reina, G. A., Edwards, B., Martin, J. & Bakas, S. Multi-institutional deep learning modeling without sharing patient data: a feasibility study on brain tumor segmentation. In *International MICCAI Brain Lesion Workshop*, 92–104 (Springer, 2018). https://doi.org/10.1007/978-3-030-11723-8_9v

[3] Sheller, M. J. et al. Federated learning in medicine: facilitating multi-institutional collaborations without sharing patient data. *Sci. Rep.* **10**, 12598 (2020). https://doi.org/10.1038/s41598-020-69250-1

# FINAL THOUGHTS

## FL POWERED BY NVIDIA + DELOITTE CAN ENABLE A PARADIGM SHIFT IN CDC'S CURRENT PUBLIC HEALTH FORECASTING CAPABILITIES



### PRIVACY

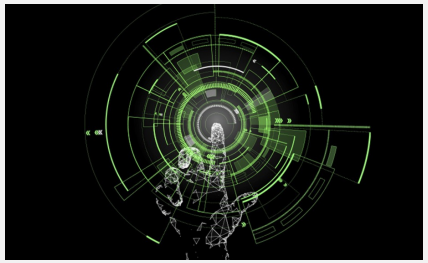
*FL allows partners to retain ownership and control of their data, reducing the need for negotiation of complex data use agreements and transfer processes*

### COLLABORATION

*FL can facilitate and simplify collaborative efforts across a complex network of STLT and healthcare partners to unlock new insights and enhance knowledge sharing*

### INNOVATION

*Federated learning can enable training of algorithms that significantly outperform current approaches using siloed data sets*



### EASE OF USE

*NVIDIA FLARE's SDK facilitates adaptation of existing ML pipelines and includes fine-grained provisioning and access controls, making FL easier to deploy and manage across many heterogenous participating sites*

# Deloitte and NVIDIA Alliance for Public Sector

## *Solving Today's Challenges by Accelerating AI Innovation*

The government is facing new challenges, demanding intelligent solutions that legacy methods can no longer solve. Together with NVIDIA, Deloitte is bringing your agency the AI and accelerated computing experience needed to enable success in the government's modern-day missions.

### VALUE OFFERING

***Speed:*** Accelerated AI enabled by pre-trained solutions reduces development time to more quickly deploy a solution in the marketplace.

***Intelligence*:** AI models provide real-time analysis, pattern identification, data interpretation and other intelligent functions to reveal insights with greater accuracy and cost efficiency.

***Support*:** Together, the Deloitte-NVIDIA Alliance pioneers intelligence with clients and creates value by innovating and building AI solutions; opening new frontiers in the market; and creating solutions that enhance efficiency and engagement.

### APPLYING ACCELERATED AI INNOVATION

#### Cybersecurity

The Deloitte and NVIDIA Alliance helps deliver AI-powered solutions that bring a new level of information security to the data center, cloud, and edge. NVIDIA Morpheus uses AI to identify, capture, and act on threats and anomalies that were previously impossible to identify.

#### Training and Simulation

Digital twins allow agencies to build and simulate virtual environments in order to power better, more informed decision making. By synchronizing to physical places, processes or people, your agency can stay one step ahead.

#### Autonomous Systems

NVIDIA Edge AI can process data at-site to reduce latency, increase accuracy of feedback mechanism, and continuously train models i.e., remote image detection, autonomous and robotic systems. Protect your agencies assets with real-time, actionable insights.

### WHAT DELOITTE DELIVERS

- Capabilities in accelerated computing
- Proven practices for building valuable AI
- Experienced guidance on model management
- Leadership in identifying AI use cases
- Consideration for developing ethical AI



GPS NVIDIA Alliance LAP
**Rashmi Mathur**
rashmathur@deloitte.com


GPS NVIDIA Alliance Growth Leader
**Alison Voss**
avoss@deloitte.com


GPS NVIDIA Alliance Manger
**Taylor Hope**
tahope@deloitte.com


GPS NVIDIA Alliance Technical Champion
**Kyle Harbacek**
kharbacek@deloitte.com