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Federated AI lets a team imagine together: Federated Learning of GANs

Rajagopal. A[1], Nirmala. V[2*]

[1] Interdisciplinary research, Indian Institute of Technology, Madras, India
[2] PG and Research Dept. of Physics, Queen Mary's College, Chennai, India

[*]*Corresponding Author: gvan.nirmala@gmail.com, Tel.: +91 9445412134*

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***Abstract*—** Envisioning a new imaginative idea together is a popular human need. Imagining together as a team can often lead to breakthrough ideas, but the collaboration effort can also be challenging, especially when the team members are separated by time & space. What if there is a AI that can assist the team to collaboratively envision new ideas?. Is it possible to develop a working model of such an AI? The contribution of this paper is to develop such an intelligence. This paper proposes a formula to design such a creative & collaborative intelligence by employing a form of distributed machine learning approach called Federated Learning along with Generative Adversarial Network (GAN) fusion. This paper demonstrates this novel deep learning architectural paradigm by developing a practical working prototype. The outputs of the prototype of this novel AI paradigm in showcased in this paper. This collaborative creative AI presents a new paradigm in AI, one that lets a team of two or more to come together to imagine and envision ideas that is mutual liked by all team members as well one that synergies well with each other's likes. This was possible by a completely new way to combine federated learning with an interesting new way to combine multiple GAN together. In short, this paper contributes a novel type of AI paradigm, called Federated AI Imagination one that lets geographically distributed teams to collaboratively imagine new possibilities.

***Keywords*—** Artificial Intelligence, Distributed Machine Leaning, Generative Deep Learning, Generative Adversarial Networks, Federated learning, Creative AI, AI based Collaboration, AI planning

I. INTRODUCTION: FEDERATED AI IMAGINATION

A. Future of AI: Colloboratively invent new possibilities

Table 1: How is this paradigm different?

	Functionality	*References*
Current state of art (2017 to May 2019)	AI learns using a set of users	FL by Google [1]
Contribution of this paper	A set of users use AI to Imagine together	This paper

Is it possible for a team to use AI to imagine ideas. This paper explore this new paradigm, and demonstrates it is feasible. So far Federated Learning (FL) by Google[1] performs classification tasks by learning from a group of user's data. But what if the goal of AI is help a team of users to jointly imagine together? Is this possible for AI to do?.

B. Paper Contribution: A novel AI paradigm, FL weds GAN

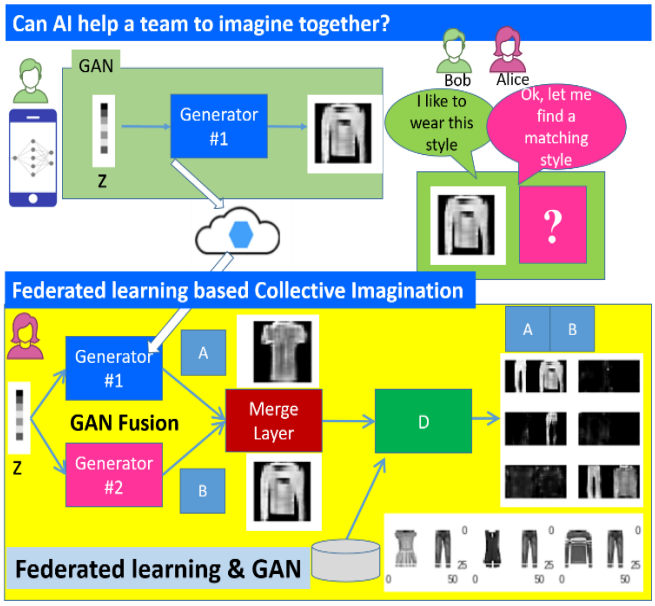

Figure 1: FL and GAN fusion, a new neural net for paired object synthesis.

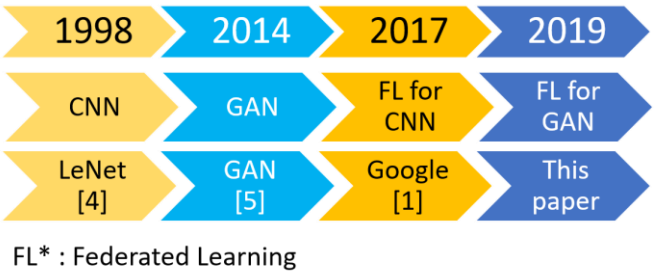

Figure 2. How this paper shapes Federated Learning research direction

The 5 major contributions of this paper are

1. Shape the future direction of Federated Learning research, as illustrated in Figure 2
2. Expand the scope of what is achievable by AI as per Table 3
3. Proposed a novel Deep Learning architecture for Collaborative Imagination for a team.
4. Demonstrate the feasibility of the proposed architecture by developing a working prototype.
5. Showcase the possibilities of Federated AI with results.

The main contribution of this paper is to shape the future direction of Federated Learning (FL) research, as illustrated in Table 1. By introducing a new paradigm of an AI that enables collective human imagination, a new wave of possibilities are let open by this paper's contribution.

C. Realted work & Where is the Gap?

Table 2: Gaps in research

	Functionality	*Deep Learning architecture*	*References*
State of art *2017 to May 2019*	A set of users Learn together	TensorFlow Federated framework by Google [2]	FL by Google [1]
Research Gap	A set of users Imagine together	Contribution of this paper	This paper

FL [1] introduced by Google in 2017 is an active research area. In 2019, Google released TensorFlow Federated at "tensorflow.org/federated". So far, FL has been used in classification tasks. But can FL be used in synthesis tasks? This paper explores this new possibility and presents the results. This work contributes a novel Deep Learning architecture for combined imagination by a team.

This is the first paper to combine FL with Generative Adversarial Networks (GAN) [3].

D. What is the significance of this paper? What is the potential impact of the proposed AI approach?.

Table 3. This paper expands the scope of possibilities for AI

What type of problems can be solved by the proposed AI approach?		
Federated AI Imagination		
	Proposed AI Capability	***Example Challenges***
1	***Collaborative Planning (Collaborative Envisioning)***	A husband and wife want to plan which apparel to wear for the party, based on an understanding of the typical dress patterns of others.
2	***Paired Image synthesis***	Which couples usually go together?
3	***Sports partnership analysis***	In sports, which players partner together most?
4	***Collaborative Contemplation***	In smart city security, if you spot a terrorist in a camera in one part of the city, where is his partner?
5	***Imagining the future based on Cause and Effects.***	Imagining a Future event, given a particular event has happened

This paper opens up the immense potential for AI in many dimensions.

1. AI for Collaborative Envisioning (Planning)
   - Figure 1 & 5 illustrates how a family thinks together to plan for an occasion
2. AI for Collaborative Deliberation (Contemplation)
   - Figure 3 illustrates how multiple city security cameras federate and imagine together to improve security of the city.
3. AI for Cause and Effect prediction and Visualization
   - Figure 8 explores how cause and effect relations across geo distributed events.

The paper is organized as per the above 3 themes in the order.

II. THE SECRET FORMULA: HOW TO DESIGN DEEP LEARNING ARCHITECTURE TO OPEN DOORS FOR FEDERATED AI IMAGINATION

What is the secret formula behind this AI paradigm? How to realize the possibilities of Table 3. A novel Deep Learning architecture to accomplish this is contributed by this paper. The idea behind this architecture is to combine the power of FL and Generative Adversarial Networks (GAN) multimodal fusion. This paper designs the deep learning architecture for the above AI paradigms and develops a working model. This novel neural network architecture is presented in Figure 3 and Figure 7.

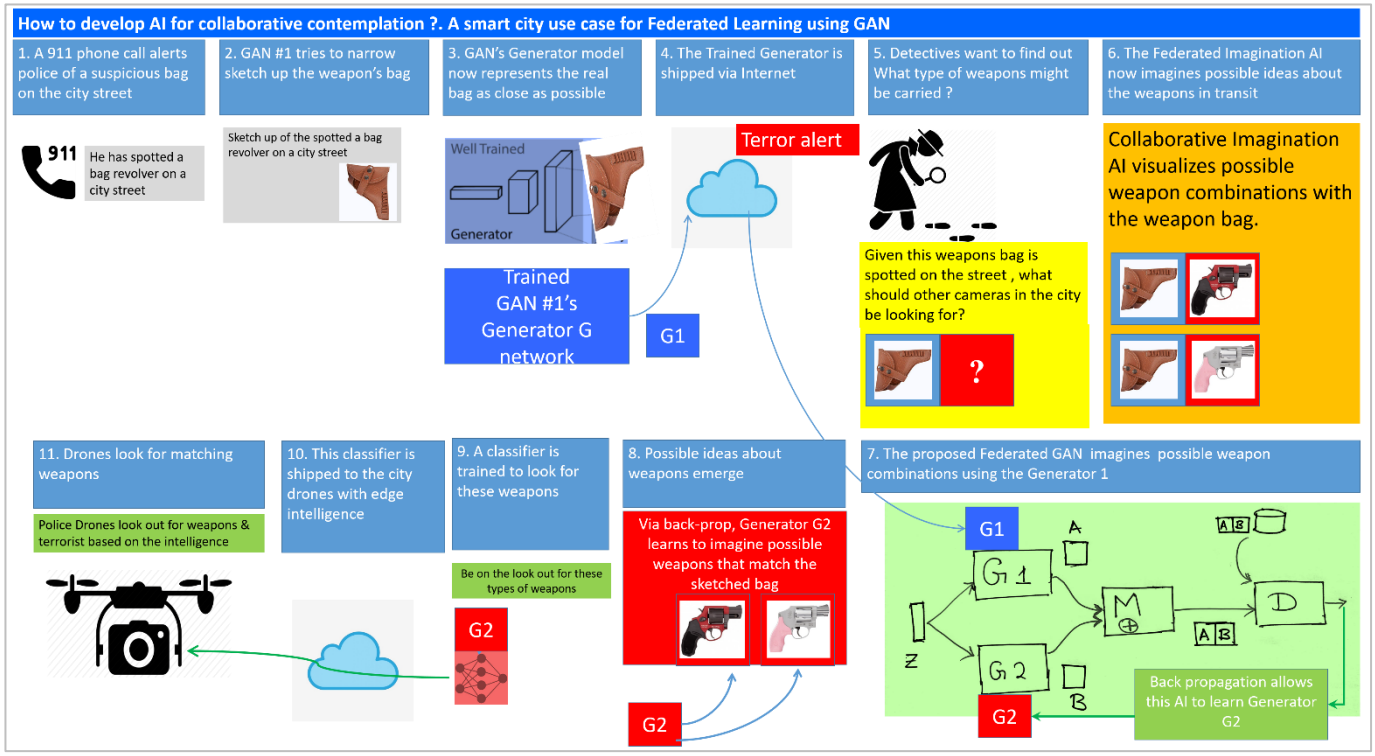

Figure 3. How to develop AI for collaborative thinking. The secret sauce behind this new AI capability is illustrated.

A. The secret formula: Is it the union of FL & GAN Fusion?

The secret formula for **Federated AI Imagination** is presented in Figure 3 with a use case. How to design a city scale AI architecture that allows a collective team to perform a team activity. The challenge here is AI for counter-terrorism.

1. A GAN based Generator G1 is trained to sketch up a weapon's visual that was spotted.
2. G1 is trained & uploaded into cloud to facilitate FL.
3. The model G1 get downloaded over internet and gets dynamically federated into a GAN Fusion neural net, as shown in module 4 in Figure 3.
4. The GAN Fusion model merges few generators, G^i from multiple users. Each G can be a trained by a user on another device and dynamically federated over internet. The design for GAN Fusion is shown in module 7 in Figure 3. G1 has insights about imaginative sketch of bag as imagined by first user. G1 is frozen inside the Fusion network as they represent user's interest. Next, the goal is to use back propagation on the Fusion network. This allows G2 to learn, given G1 is non-trainable now.
5. After learning, G2 will be able to imagine possible weapons that would have been carried in that bag.
6. This intelligent imagination patterns by this Federated AI is transmitted to drones for city surveillance.

The architecture showed how imagination power of humans is handed over internet into a Fusion GAN, allowing further imagination. This is the essence of the idea of using FL with GAN Fusion. Thus Federated AI Imagination by a team has been designed.

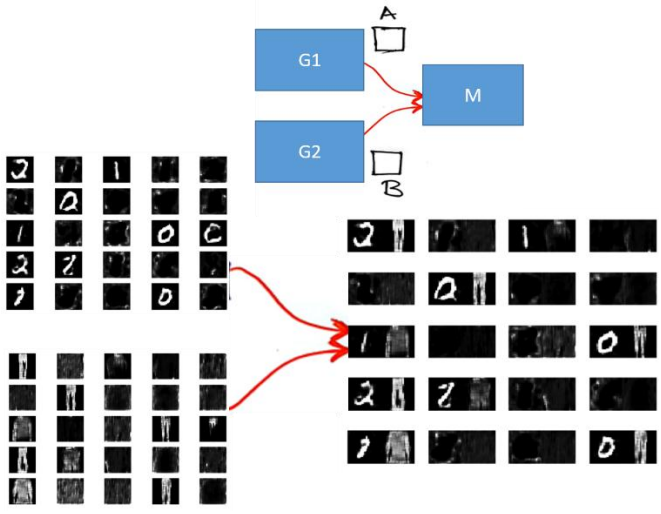

Figure 4. Screenshot of output of GAN Fusion.

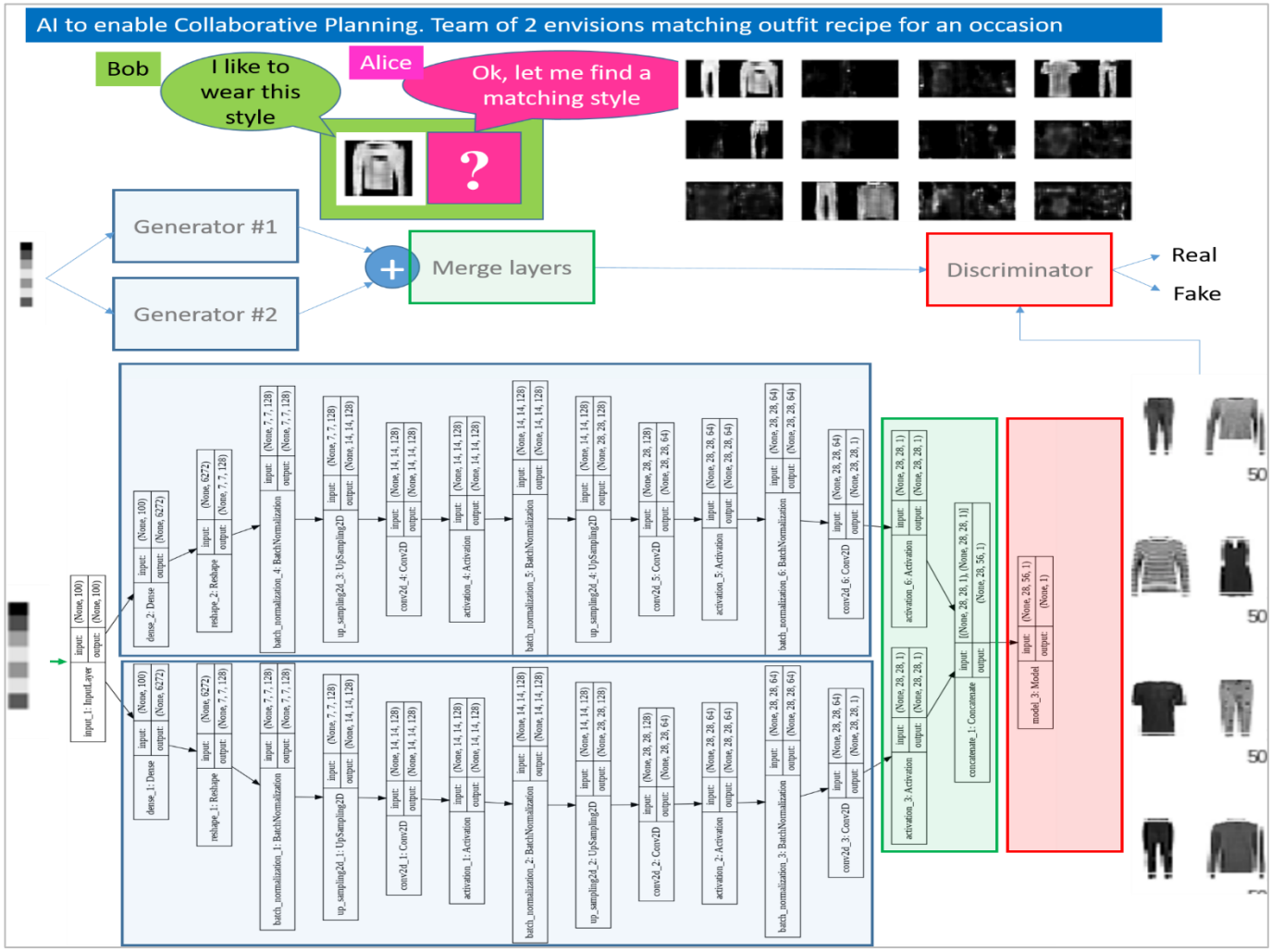

Figure 5. Implementation of GAN Fusion architecture. This powers Collaborative AI Imagining by a team

B. *The secret formula behind AI that Colloboratively Imagines: A working prototype brings the formula alive*

At the intersection of two promising active research areas, FL & GAN based Neural Network Fusion approaches, is the discovery of the promise of AI that powers **Collective Imagination** by a team. A working prototype of AI that enables a team to imagine together is developed. The holistic architecture for how GAN Fusion and FL comes together is discussed in Figure 3. An implementation of GAN Fusion on is shown in Figure 5. As per Figure 5, key tricks are both Generators are sampled from the same noise vector, Generator #1 is frozen, so that Generator #2 learns during back propagation, Discriminator uses a new type of dataset, which has possible combinations of the 2 images. The results of the working prototype is presented in Figure 4.

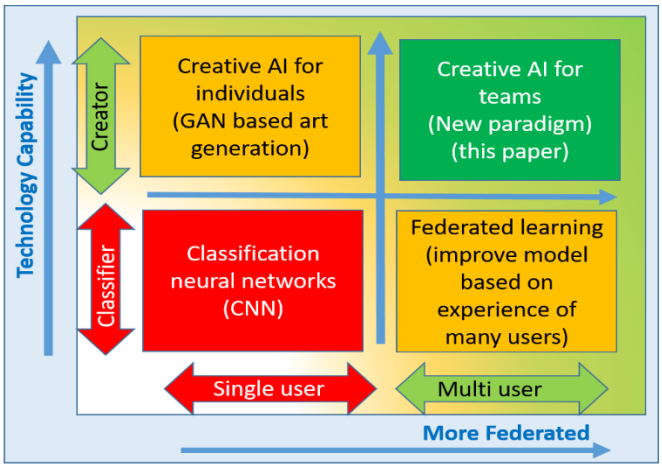

Figure 6. This work is at the juncture of 2 promising research areas, FL & GAN Fusion

III. How to Design a AI to Understand Cause and Effect across Geos, and Visuvalize the Future

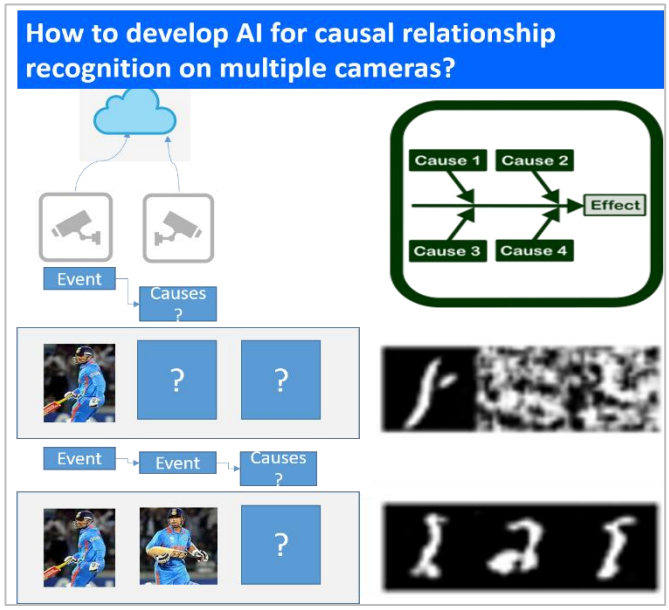

Figure 7. AI that can predict & visualize the future across geos

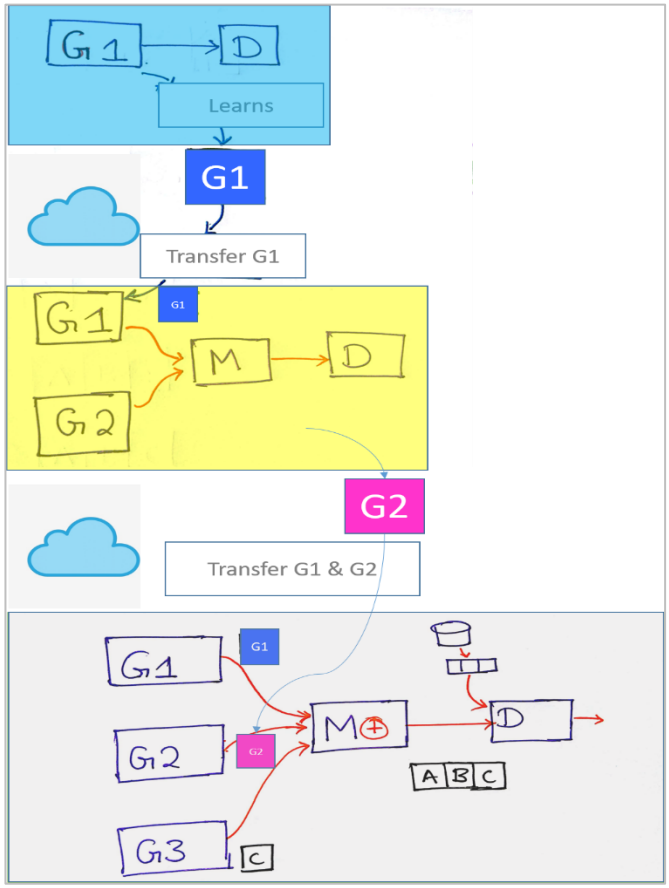

Figure 8. Federated Learning over cloud enables multiple users to participate during Collaborative Consulting.

How to develop AI that predicts the future from a set of geo distributed robots/cameras? Is it possible for a GAN Fusion to find patterns of cause and effect? Is it possible to create an visualization of the future given past events across many parts of the city?. The challenge presented in Figure 7 is approached by the formula of innovatively repeating a geo distributed computation graph. This algorithm is listed in Table 4. By repeating the FL based GAN Fusion distributed computation graph at periodic intervals, this AI achieves the feat of picturing the future based on patterns observed in the past across different parts of the city.

Table 4. FL based Deep Learning algorithm for predicting the future based on events happening across spatial dimensions

Federated Deep Learning Algorithm to correlate events across geos and visualize the future		
1	2 stages of GAN Fusion is hired, as shown in Figure 8	
	1.1	In the 1st stage of GAN Fusion, G2 learns to visualize the future based on intelligence gather by G1
	1.2	Once the 1st stage is trained, G1 and G2 are transmitted over the internet for fusion at next stage
	1.3	In the 2nd stage of GAN Fusion, G3 learns to visualize the future based on happenings in previous 2 locations as represented by G1 & G2
2	Thus, Generator G3 learns the causal relationship between 3 locations	
3	G2 even can start predicting based on trick listed below	
4	G3 even can start predicting and visualizing the future by the below trick	
	4.1	Every few minutes, the Federated learning transmits G1 and G2
	4.2	Meanwhile G1 & G2 counties to learn
	4.3	Then G3 learns to match patterns in the 3 locations based on intelligence of G1 & G2
5	Repeat steps 1 to 4 again in a loop	
6	G uses a spatio temporal model, I3D / 3DCNN [15]	

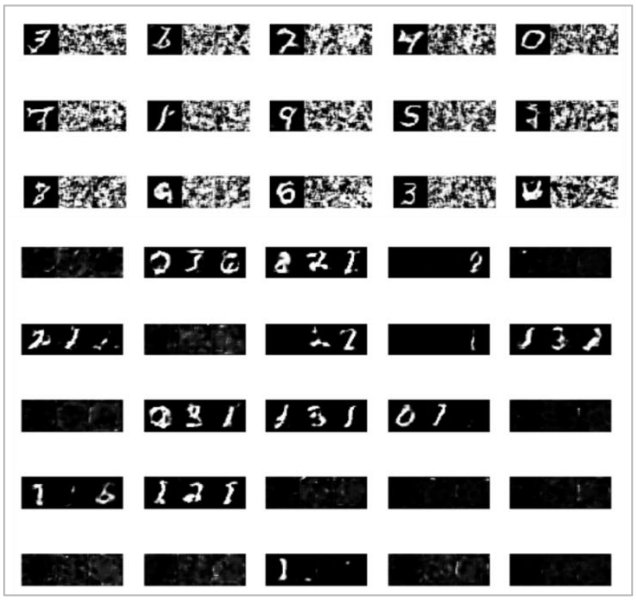

Figure 9. Screenshot of output for prototype of an AI that visualizes future events by combing intelligence gathered across multiple locations.

IV. RESULTS AND SUMMARY OF CONTRIBUTIONS

Key results and contributions are

1. Contributed a new flavor to FL research as per Table 5
2. Expanded the potential of Federated AI as per Table 6
3. Contributed a novel Federated Deep Learning approach for Collaborative Imagination for a team as per Figure 7.
4. Demonstrated feasibility of Federated Imagination with a working prototype. Figure 5 shows screenshots.

Table 5. Key contribution in Distributed Machine Learning research

Paradigm	Objective of AI	Design	Benefits
Federated Learning	Learn to pattern by training on multiple user's data for better recognition classification	FL with DNN or CNN	AI learns while protecting user's Privacy
Proposed architecture	Collaborative Imagination / Synthesis /	FL with GAN	Collaborative planning tasks

V. CONCLUSION AND FUTURE SCOPE

Table 6. What is attainable by AI will change due to this paper

Expanding the possibilities of Federated AI		
	Contributed AI Capability	**Results**
1	***Collaborative Planning***	AI Capability is demonstrated as per Figure 5.
2	***Collaborative Contemplation***	AI Capability is demonstrated as per Figure 3.
3	***Imagining the future based on Cause and Effects.***	AI Capability is demonstrated as per Figure 7.

Much promise holds for the future of AI as FL weds GANs. Federated Deep Learning with GAN Fusion is a new paradigm and sets the stage for new dimension in AI research, as discussed in Table 5 and 6. AI practitioners in the industry can use this paper as reference, while AI researchers will see breakthrough as per Table 3.

VI. NOMENCLATURE

Table 7. Nomenclature used in this paper

NOMENCLATURE	
GAN	Generative Adversarial Network [3]
FL	Federated Learning [1]
G	Generator of a GAN
G1	Refers to model generator G of 1st user
G2	Refers to model generator G of 2nd user
M	Merge layer (keras)
D	Discriminator of GAN
TFF	TensorFlow Federated Framework by Google

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Authors Profile

Rajagopal A , BTech from IIT Madras, MS from IISc, is currently research scholar at IIT Madras.

Nirmala V works as an Assitant Professor at PG & Research Dept of Physcis at Queen Mary's College, Chennai.

