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Autonomous Self-evolution of AI on drones: Transfer Learning of Neural Architecture Search's brain

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***Abstract*—**Biological creations adapt to environmental changes. Similarly, can autonomous AI system adapt to the environmental changes? During natural disasters such as floods or cyclones, an autonomous robot might unexpectedly face new conditions such as occlusions from dust, and hence may need to adapt itself. Is it possible for a drone flying into a disaster zone to autonomously evolve itself without any human guidance. Many times autonomous AI systems may be exposed to new conditions that it hasn't yet been trained. How to provision full autonomy to such autonomous AI?. This is the challenge this paper answers. Disruptions in internet connectivity during disasters add an additional dimension to this challenge. How does the AI on drone self-adapt during disasters? Is it possible to employ Neural Architecture Search (NAS) for autonomously evolving the drone's intelligence to the new environment?. With internet outages during disasters, is it possible to evolve the AI by evolving the model locally on the drone?. In short, this paper explores how to design autonomous drones that can triumph over disasters, by autonomous evolving the drone intelligence to the new environment using NAS.

***Keywords*—** Artificial Intelligence, Autonomous systems, Neural Architecture Search, AutoML, Transfer Learning

I. INTRODUCTION: WHY SELF-EVOLUTION OF AI?

A. Can AI serve humans during natural diasters?

During emergencies such as earthquakes, floods, cyclone, autonomous systems have a prominent role. Should an ambulance drone be given the power to self-evolve to save a live, while it is operating in disaster relief missions?

B. Related work: Trends in automated evolution of AI

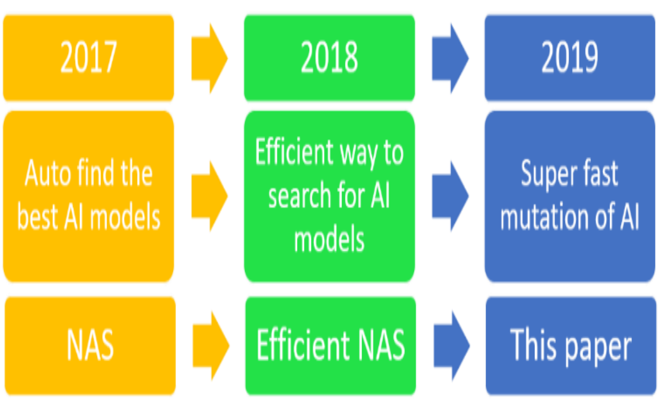

Figure 1. Trends in automated evolution of AI

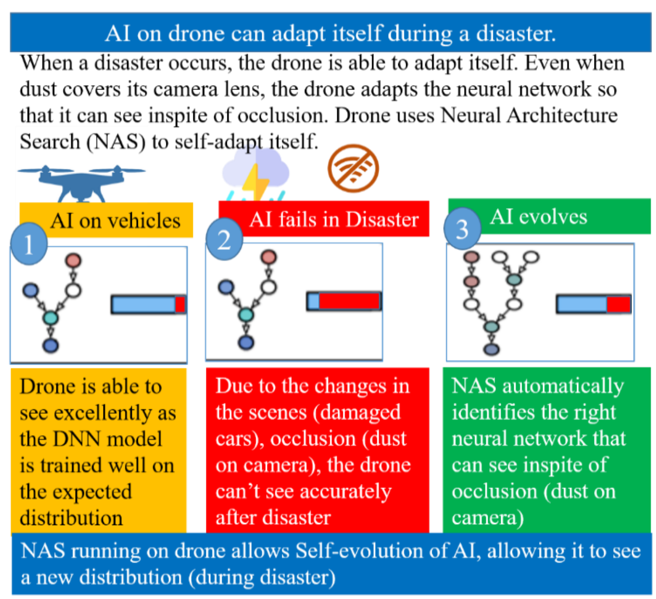

Figure 2. Ambulance drone endures a cyclone through self-adaption of AI.

This paper contributes a vision for **automated Self Evolution of AI**. Fig 2 illustrates this vision. Autonomous drones are exposed to new conditions in disasters. For

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instance, a dust on camera challenges drone's ability to see. Can the drone's AI adapt itself to the new condition?. Refer Fig 1 for related work.

C. Challenges adressed by this paper

This paper addresses two challenges listed in Table 1 & 2.

Table 1: Challenge #1

	Challenge #1	*Proposed Solution*
1	During disaster, the AI may misclassify because of dust on drone's camera lens	AI automatically self-adapts to the new environment by self-evolution.
2	No internet connectivity after disasters	

Table 2: Challenge #2

	Challenge #2	*Proposed Solution*
1	NAS typically runs on cloud (needs 100's of GPUs for many days)	How to implement self-evolution on a drone by employing NAS? (Neural Architecture Search)
2	How to run NAS on the resource constrained drone? How does the AI self-evolve if offline from internet?	

D. Darwin's theory meets AutoML: Challenge #1

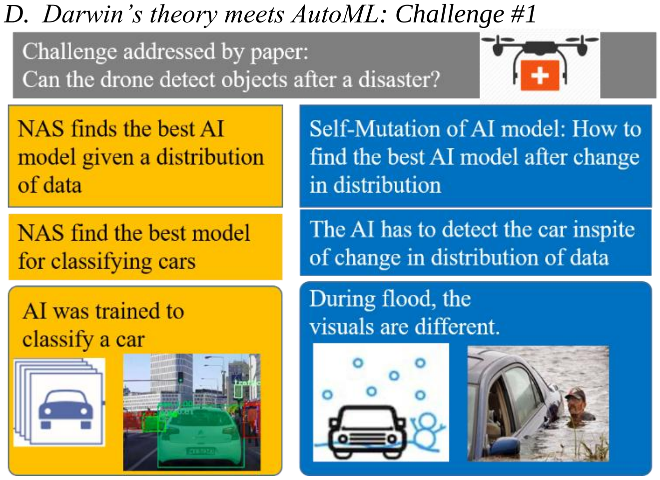

Figure 3. Change in city's visuals after a disaster. Can a drone adapt?

Similar to how nature evolves by genetic mutations of biological organisms, is such self-evolution of AI possible? An ambulance drone on a relief mission after a natural disaster may lose the network connectivity to its master. But to save a human life, it can explore the possibility of changing its own genetic code (the neural network) to suit the new environment (new distribution of the dataset). Refer Table 1.

E. Self-evolution on drone while offline: Challenge #2

Sporadic internet connectivity during disasters can disconnect the drones from human control room. AI systems evolve by using Network Architecture Search (NAS). Typically NAS runs on the cloud, and requires enormous compute resources and enormous time. For instance, NAS by Google brain researchers used enormous cloud computing power, specifically 450 GPUs for 4 days as per their CVPR 2018 paper [1]. But an autonomous car or a drone may have only a handful of GPUs and needs to evolve within few hours. Google team proposed an efficient way to implement NAS with the ENAS [2]. ENAS demonstrated a 1000x speed up in NAS. ENAS was able to find model with a single GPU under 16 hours [2]. ENAS used a novel approach of parameter sharing among child models to improve the efficiency. But during a disaster rescue mission, an ambulance drone can't wait for 16 hours for ENAS. Is there a quicker way to self-adaption? So is there super-fast approach to adapt? This is the 2nd challenge addressed by this paper.

F. Organization of this paper

The paper presents the need for automated AI self evolution, then the challenges, and the proposed AI solution architecture.

II. SOLUTION: AUTOMATED SELF-EVOLUTION OF AI

A. The technique: Self-Evolution of drone's AI by transfering the wisdom learnt by NAS to the drones.

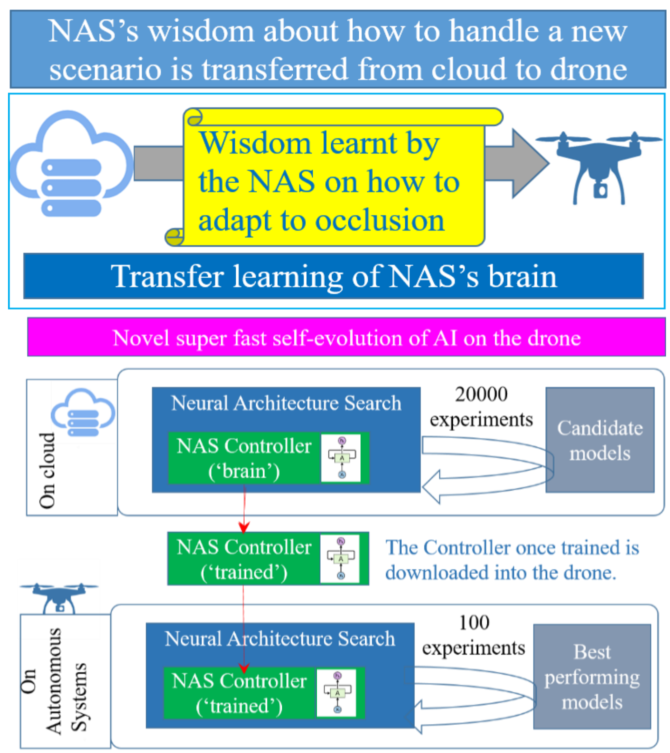

Figure 4. Core algorithm for superfast self-evolution of AI

If the drone's AI needs to evolve, it needs to happen in few hours. So Neural Architecture Search on the drones needs to be a super fast algorithm. To do **super-fast AI evolution**, the trick is tap into the intelligence learnt by NAS's Controller on the cloud. Such a transfer learning of NAS's RNN from cloud to drone allows superfast autonomous evolution. Figure 4 discusses this proposed trick.

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B. Automated Self-Evolution of AI: Is it even possible?

Is it possible to change its AI autonomously without human guidance? The need for **autonomous self-evolution of drone** was emphasized in Figure 2 and Table 1. What does it take to design automated evolution of AI while the drone is offline from internet? The paper contributes the architecture for **Automated Autonomous evolution of AI** in Figure 5.

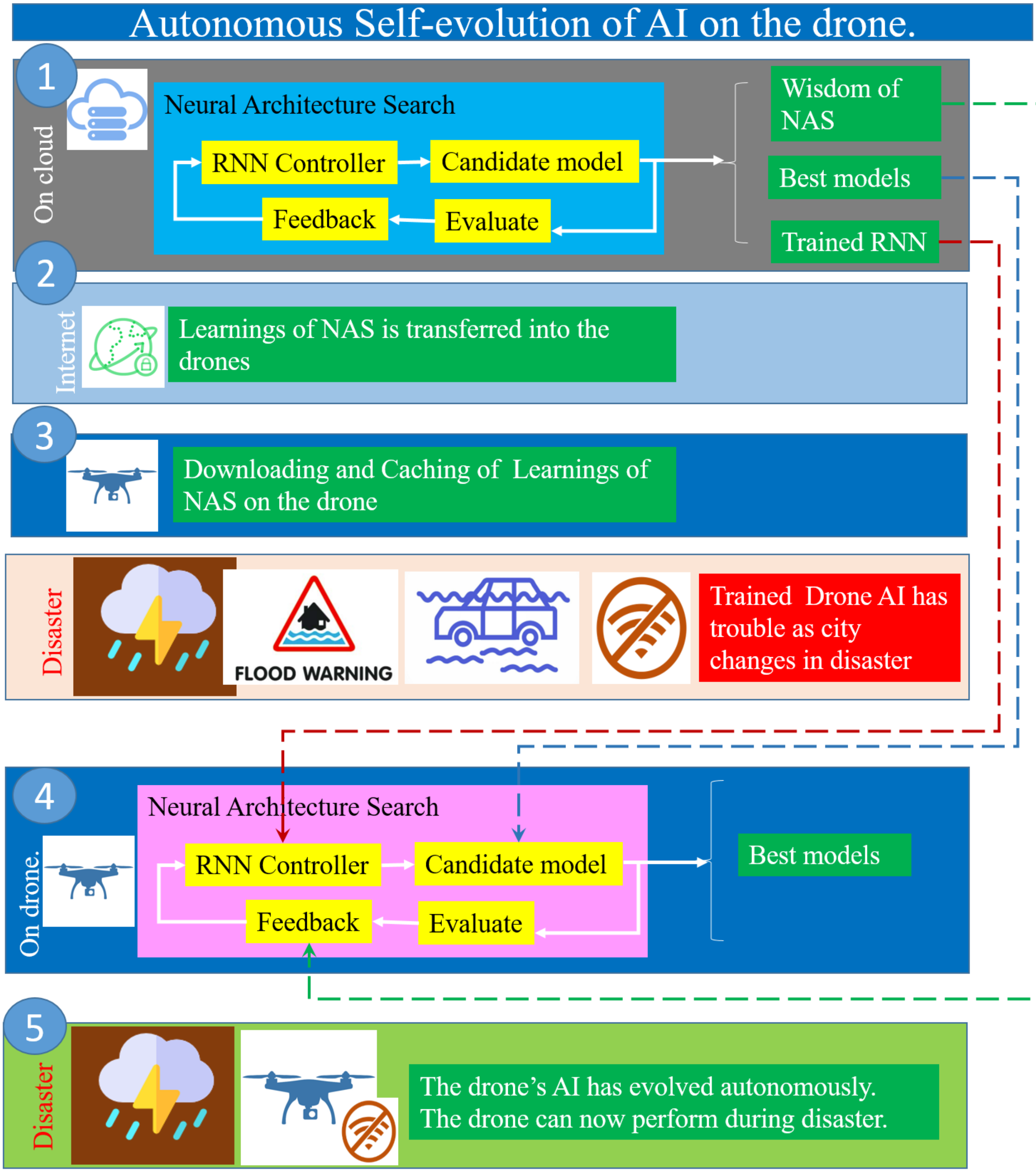

Figure 5. A paradigm in AI: Automated Autonomous evolution of AI

C. Goverance policy to control autonomous evolution of AI

To prevent any harm to humans, a governance policy is employed to control the autonomous evolution. The policy checks the necessity for self-evolution of AI. Permission to proceed with autonomous self-evolution happens if:

- The drone is on a mission to save a human life like an search and rescue operation after a diaster.
- Sporadic internet connectivity during disasters has disconnected the drones from human control room[13].
- The distribution of the dataset has changed as the city landscape after a disaster. Refer Figure 3.
- Due to dirt on the lens of the drone's camera, AI has misclassifed as shown in Figure 6.

III. AUTONOMOUS SELF-EVOLUTION OF DRONE

A. How Self-Evolving AI takes on a specific challenge

This section of the paper illustrates how the proposed Self-Evolving drone is able to adapt to new condition after a cycle, specifically there is a dirt that occludes one of the stereo camera. This causes visual occlusion as shown in Figure 6.

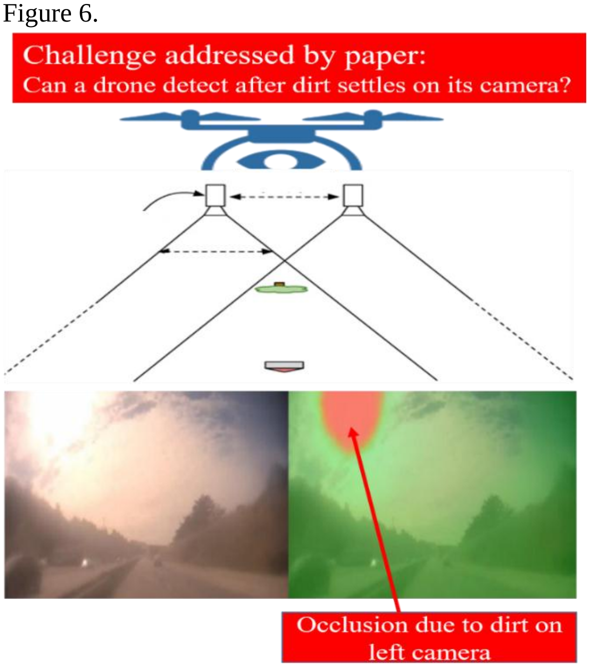

Figure 6. Can a drone adapts itself to handle a challenge?

B. Automatic Autonomous Self-Evolution of AI

A vision for **autonomous self-evolution of AI** on autonomous systems is presented in this paper. In this vision, autonomous drones get the power to self-adapt itself, even when there is no internet connectivity. A novel architecture to realize this vision of AI self-adaption is illustrated in Figure 5. For the challenge listed in Figure 6, the solution for automated autonomous self-adaptation is presented in Figure 7. The AI can train itself automatically using 2[nd] camera and evolve autonomously using NAS.

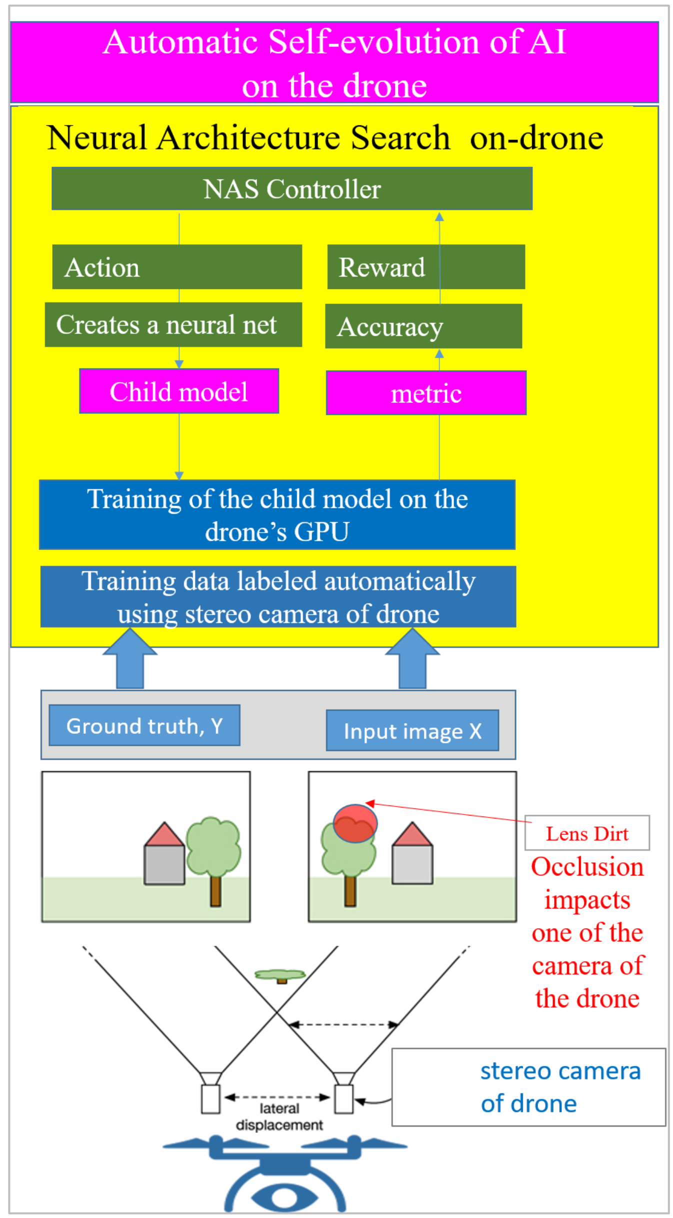

Figure 7. A novel idea to automate the evolution of drone

C. Algorithm: Transfer learning of NAS's RNN to drone

How does the drone quickly self-adapt to a new challenge? The trick is to employ transfer learning to transfer the wisdom of cloud-NAS-Controller to drone-NAS-Controller. Here is the algorithm:-

1) The cloud-NAS-RNN Controller is trained for various new conditions such as occlusion.
2) The intelligence of cloud-NAS-RNN Controller is copied to the drone. This transfer of intelligence (RNN Controller) from cloud to drone can be viewed in Figure 5, Figure 8 and Figure 9.

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3) Even when the drone is offline from internet, the drone is able self-adapt using the intelligence (RNN Controller) it has inherited from cloud. Refer Figure 9.

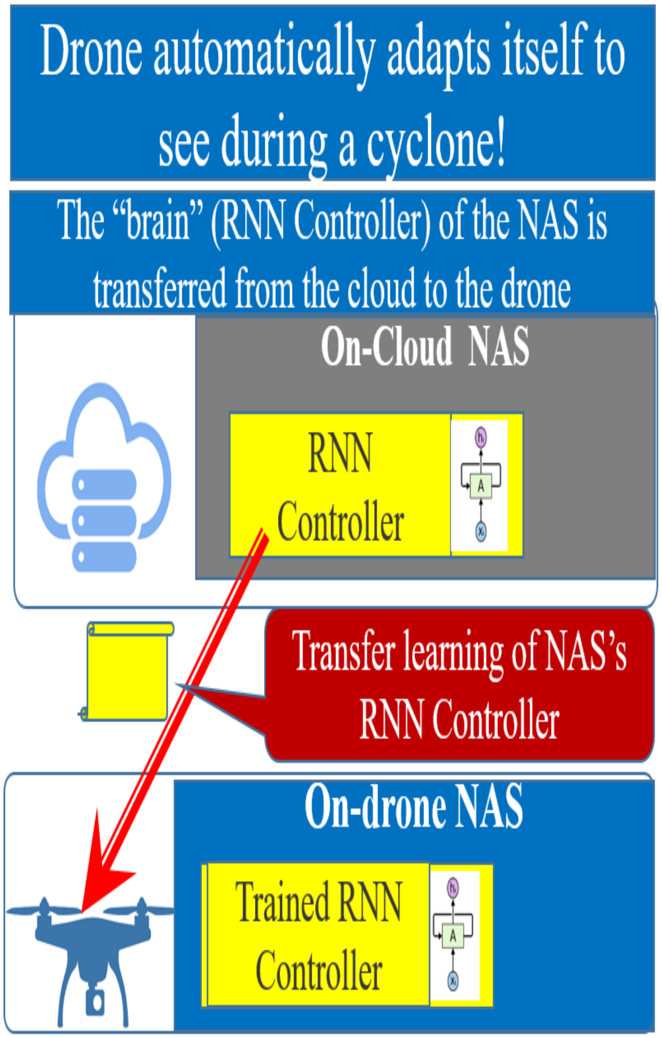

Figure 8. How a wisdom of a trained RNN to handle occlusion allows the drone to quickly self-adapt to dirt on its stereo camera

D. Related work & Gap

Amazing progress is being made in NAS[11] as shown in[1],[4],[5]. ENAS [2],[7],[8] improves efficiency of NAS. This paper differs in how NAS is utilized. The objective of this paper is self-adaption of AI during disaster relief operations by autonomous systems, hence the need for self-adaption. The novel idea is in transferring the NAS's RNN Controller from cloud to drone, thus allowing autonomous self-evolution[14] while the drone is offline from internet. Transfer learning is popularly used technique, but this paper explores the idea of transfer learning[15] for NAS's RNN Controller to implement superfast adaption.

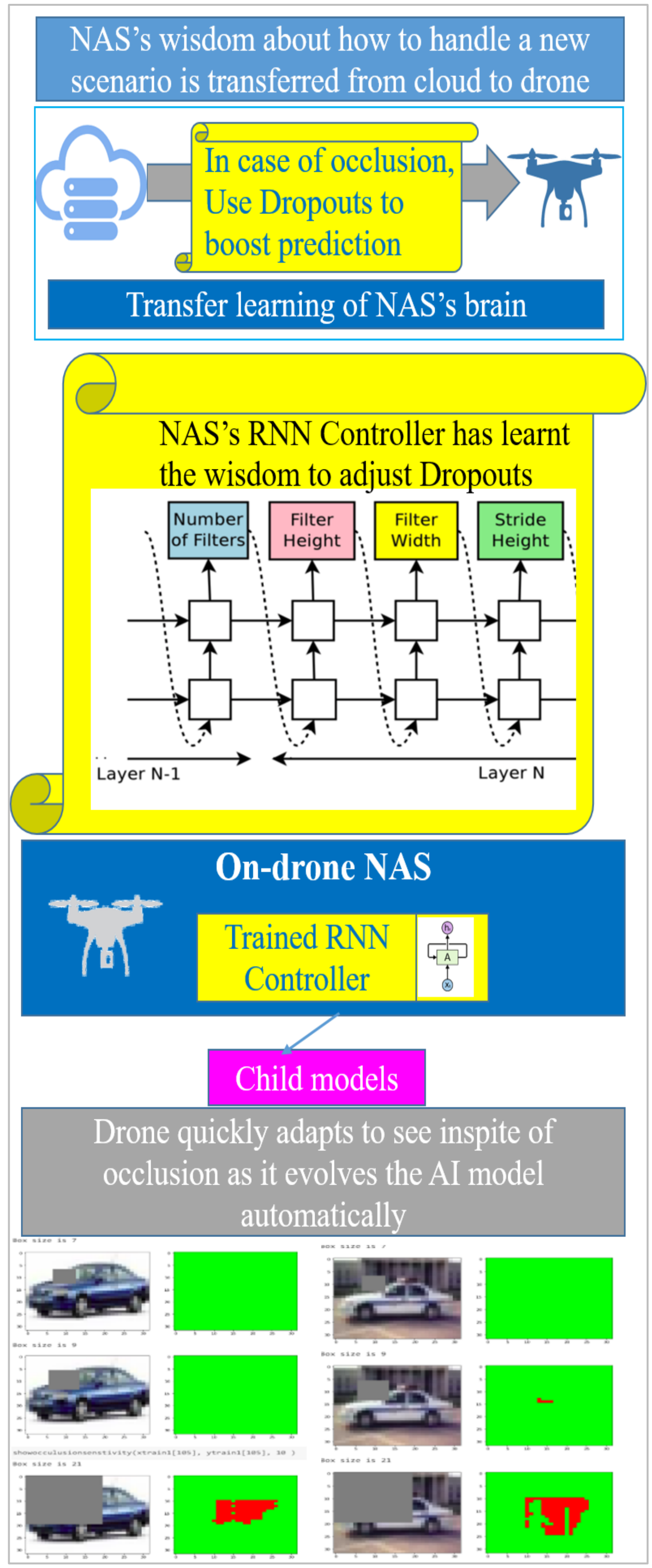

Figure 9. How the drone self-adapts.

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E. Future: Self-evolving drones

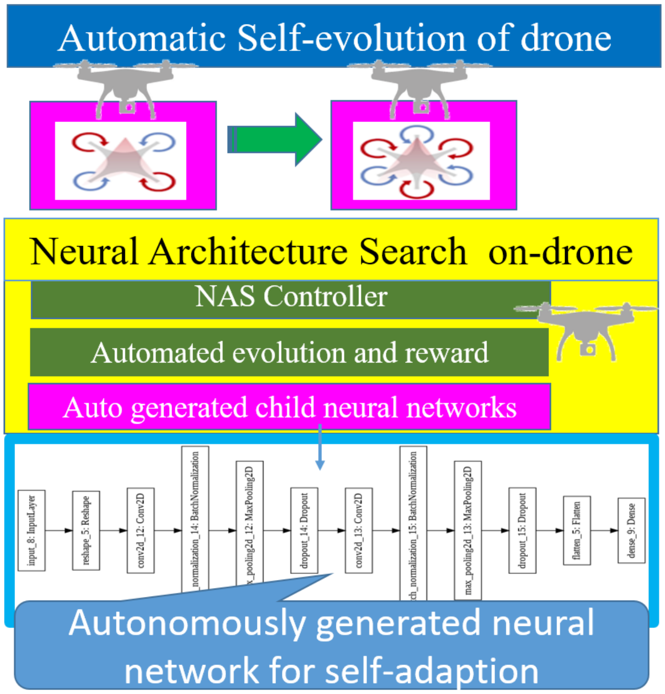

Figure 10. Future drones can self-adapt as and when required

IV. Conclusion

This paper presented a vision towards **Autonomous Self-Adaption of AI**, a vision for enabling autonomous systems to self-adapt after a disaster, so that they can evolve and help humans after a disaster. Given the distribution of dataset may change after a disaster, and internet outage, this paper explored how autonomous AI systems can automatically evolve after disasters, without human supervision. Thus drones can accelerate relief operations during disaster. This way intelligent systems can self-adapt to changes without much human intervention, similar to biological evolution.

In summary, the key contributions towards **Autonomous Self-Evolution on AI on autonomous systems** are

A. *Vision*: Why and when to use self-evolution of AI? Life saving drones after diasters with a goverance policy may be permitted to self-adapt. The self-adaption goverance policy is presented in section II.C. The concept of self-adapation is presented in Figure 2.
B. *Challenge addressed:* How does a drone self-evolve? Novel solution architecture to automate autonomous self-evolution of AI is presented in Figure 5.
C. *Architecture:* Given the need for super fast evolution on drones, transfer learning of the Controller of NAS from cloud to drone is used. Refer Figure 4.
D. *Design for automatic evolution:* Technique for automatic self-evolution using Nerual Architecture Search and automated creation of training dataset after the disaster is presented in Figure 7.

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