SOLDADOSS : Survivor-Oriented Learning-Driven Drone System

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Introduction:

This project, SOLDADOSS, creates a design for an autonomous search and rescue drones. We aim to help find survivors quickly in dangerous places like areas hit by natural or human desasters, for example : earthquakes, tsunamis, hurricanes, bombings, ... To acces these places, it's very risky for humans and these are places where the GPS often fails, because of it’s location or because of the desaster (obstacles), the connection is out.

Current drones aren't smart enough to fly safely through complex places. Our solution uses Artificial Intelligence (AI), specifically Reinforcement Learning (RL), to teach the drone how to navigate through these complicated areas.

The role of AI :

1. **Autonomous Flight:** The RL program learns, through loads of simulations, the best way to fly and avoid crashing into obstacles (like debris or broken walls).
2. **Smart Search:** The system uses a simple **Computer Vision** (sensors) used to look for signs of life (like heat signatures) and prioritizes its search in these directions.

SOLDADOSS proves that advanced AI can create self-controlling drones. This makes search and rescue missions faster and safer and way more economic.

1- Problem Formulation & boundaries

A. The Problem and Our Goal

The Challenge in Rescue Missions :

Finding people after a big disaster such as a big earthquake, tsunami, or structural collapses caused by a bombing. It is extremely hard and dangerous to acces these places for two main reasons:

1. It is too Dangerous for People: in case of a collapse, sending human rescuers into unstable wreckage is verry risky. They might get hurt by a second collapse, or another bombing. In the case of an earthquake, it’s the same problem. There

could be a second earthquake. If there is a tsunami, there are extremely strong currents, and the water will be very high. In this water, there could be objects floating and these may be verry dangerous.

2. The GPS Doesn't Work: Inside damaged buildings or heavy rubble, the GPS signal has a high chance that it doesn’t work. Standard drones can't fly without it and pre-made maps are useless because the area changes all the time.

This causes huge delays, and delays cost lives. This is why we need a way to search immediately and safely.

The SOLDADOSS Solution :

Our SOLDADOSS project fixes this by creating a drone that is completely **autonomous** (self-flying) and relies only on its own sensors, not on a GPS signal.

Our main goals are :

- **Maximize Search:** Cover as much of the unsearched or unkwown area as soon as possible. This could help to increase the survival chances of the injured people and it could also help locating missing people.

- **Minimize Crashes:** Fly perfectly in order to avoid hitting any debris, ensuring the mission is completed safely and with a high succes rate.

B. Why Aviation Needs This AI

Our solution, which uses AI to teach the drone how to fly through dangerous spots, is important for the future of aviation and in rescues:

- **Smarter Flying:** replaces simple automatic steps with true intelligence. Instead of following fixed rules and information, the drone uses AI to make fast decisions based on where it is located and, on its surroundings, making it much safer, easier and more reliable than any current existing systems.

- **Better Safety:** By using the drone, we remove all risks to human pilots and rescuers from the immediate disaster zone, such as collapses. Here are a few numbers that show how dangerous these rescue missions are:

Year	*Total SAR cost**	*Total SAR operations*	*Fatalities*	*Illness or injured*	*Nonillness or injured*	*Save*
2007	$4 735 424	3593	136	1218	2566	1023
2006	$4 524 875	3623	119	1445	2900	1211
2005	$4 996 705	2430	152	1129	2016	402
2004	$3 592 218	3216	127	1087	3077	815
2003	$3 468 255	3108	124	1199	2162	427
2002	$3 040 020	4537	129	1338	3492	1832
2001	$3 683 086	3619	123	1502	2782	155
2000	$2 779 967	4869	244	1471	3495	709
1999	$3 483 500	4387	211	1366	2987	1343
1998	$3 803 526	5761	122	2244	4763	1023
1997	$3 433 839	4264	225	2499	4036	1020
1996	$3 309 192	4544	297	1367	2806	953
1995	$3 061 806	3725	156	1188	3465	496
1994	$2 996 299	4821	175	1940	3746	778
1993	$4 578 521	5120	160	1868	4192	635
1992	$3 084 931	3822	159	1427	3056	390
Total	$58 572 164	65 439	2659	24 288	51 541	13 212

*SAR costs are not adjusted for inflation.

On this image that comes from ResearchGate, we focus on the fatalities and injuries of the rescuers each year. As we can see, these numbers are extremely high, and our goal is to lower or even eliminate these high numbers.

- **More Efficient Missions:** The AI finds the shortest and safest path, which saves battery power and lets the drone search a larger area in a short time, compared to methods that we use now. This makes these type of missions a lot more effective.

2 - Technical Justification

This section explains why we chose Reinforcement Learning (RL) for our SOLDADOSS drone instead of older, simpler navigation methods.

Why Traditional Methods Fail:

Older drones use methods like Rapidly using random objects in order to find paths. These methods work well when:

1. They have a map: They need a fixed plan of the area ahead of time in order to move through these areas.

2. This environment doesn't move: They cannot function when there are sudden changes.

In a disaster zone there are collapsed buildings and objects, this is why these methods don’t work:

- No Map: The area is unknown, and the drone has nothing to follow.
- Dynamic Chaos: New debris can fall, meaning the environment changes a lot in a short period of time.
- Too Slow to Calculate: Calculating a brand new path through thousands of obstacles that change all the time takes too long for the drone to fly safely.

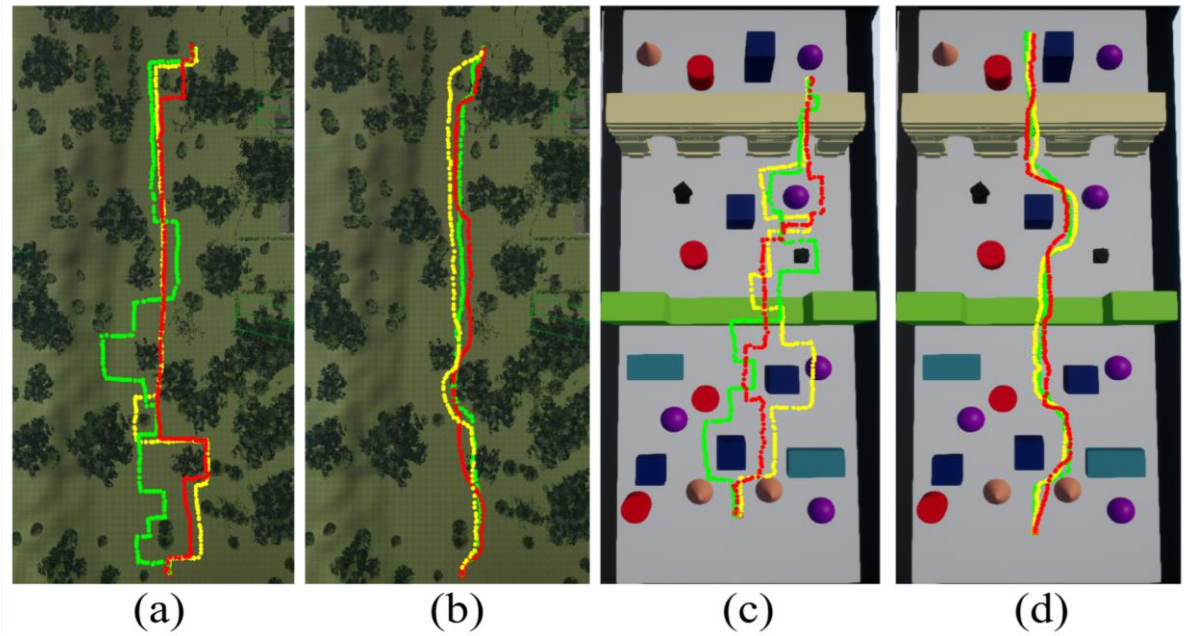
These old systems are just "automated" (they follow instructions or maps), they are not "intelligent" (they cannot learn or adapt by themselves).

Choosing Reinforcement Learning (RL):

We need an AI that can learn from experience, just like a human pilot that learns from flying (with his experience). That's why we chose Reinforcement Learning (RL).

- **Learning by Practice:** RL trains the drones by putting them in simulated disaster zones millions of times. When the drone avoids a wall or finds a survivor, it gets a "Reward" (positive points). When it crashes or wastes battery, it gets a "Penalty" (negative points).

The drone will have this type of exercise to adapt RL (to learn how to move):



- **Adaptive Intelligence:** Over time, the drone learns a set of smart rules that tells it which action is the best action to take in any situation. It doesn't follow a pre-planned route and doesn’t follow any pre-entered information: it makes safe, real-time decisions based only on what its sensors see right now. Just as if it was a real person, it thinks and acts like a human.

- **Technical Compliance:** This choice directly meets the module's goal by using a modern, complex AI technique that solves a problem where simple automation fails. RL is the only effective way to give the drone a “conciseness” that is needed to save lives in a chaotic, dangerous environment.