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Artificial Intelligence and Urban Operations

Abstract

It is widely believed that AI is about to revolutionise military operations. Many scholars have claimed that AI-enabled lethal autonomous weapons, especially drone swarms, are about to take over the battlefield. This article assesses the merits of those claims in relation to urban operations. Examining the cases of the Joint Special Operations Command in Baghdad in 2004-08 and the IDF's Operation Guardian of the Walls in 2021, it argues that AI will primarily be for military intelligence and targeting, rather than lethal autonomy.

Introduction

Artificial intelligence (AI) is about to revolutionize the conduct of warfare, as gunpowder, tanks, aircraft, and the atom bomb have in previous eras. Today, states are actively seeking to harness the power of AI for military advantage. China, for instance, has announced its intention to become the world leader in AI by 2030. Its New General AI Plan proclaimed that, "AI is a strategic technology that will lead the future."[1] Similarly, Vladimir Putin declared, "Whoever becomes the leader in this sphere will become ruler of the world."[2] In response to the challenge posed by China and Russia, the United States has committed to a Third Offset Strategy. It will invest heavily in AI, autonomy, and robotics to sustain its advantage in defense. Eric Schmidt, the former chief executive officer of Google, declared that the United States is in an AI arms race.[3] In September 2018, the Defense Advanced Research Projects Agency announced a $2 billion campaign to develop the next wave of AI.[4] The Department of Defense (DOD) issued its AI strategy in 2019 with a major increase in AI funding; In 2020, the DOD budget included a request for $927 billion for AI.[5] Smaller states are equally committed to the military development of AI; the United Kingdom and Israel, for instance, are developing their capabilities in this area.

Artificial intelligence is not always easy to define because there are many types of AI. Rather, it is a field, rather than one specific object. However, the term Artificial Intelligence refers to computer software which can develop (to some level) the ability to process data independently of immediate human direction. The distinctive feature of most AIs today is that they can develop or refine their own programs in order to complete the data-processing tasks, which they have been set, more effectively.

To understand the military significance of AI, it is useful to be aware of the history of AI. In the past fifty years, there have been two main types of AI: Good Old-Fashioned AI (GOFAI) and Second Wave AI. Good Old-Fashioned AI developed in the 1950s and 1960s. Following the celebrated Dartmouth seminar on AI in 1956, attended by luminaries like Alan Turing, computer scientists explored the possibility of programming computers to process data autonomously using symbolic logic. Scientists assigned symbolic values to the variables which they wanted analyzed. They then programmed computers to calculate those symbols based on mathematical logic. Good Old-Fashioned AI was

successful on limited tasks. However, because it relied on heavily curated input, GOFAI was narrow. It tended to collapse when confronted with the real world. The real world inevitably exceeded the symbolic coding of programmers. Consequently, after some initial success, the AI program faltered. From the 1970s to the 1990s, an AI winter fell on the field.

In the 1990s and especially after 2000, there has been a revolution in AI. Second Wave AI has generated some remarkable success. Second Wave AI operates quite differently to GOFAI. Second-generation AI relies on three key components: Data, computing power, and algorithms. Data refers to digital information held in cyberspace; it consists ultimately of an almost infinite store of binaries. The explosion of data is the key element in the advance of AI in the last few decades. Since the creation of the internet and digital communications and the proliferation of digital sensors across the globe, there has been a data explosion. Almost every activity now leaves a digital trace somewhere. It would be impossible for humans to sift through and analyze all these data. Here AI becomes crucial. Harnessing massive computing power, AI programs process these data to identify patterns or signatures. Contemporary AI does this on a purely inductive and statistical basis. Based on its data, an AI program calculates the most probable correlations. The more data, the more accurate its calculations become. AI understands nothing. It does not know what reality is; it cannot comprehend meaning. It only recognizes the frequent co-appearance of binaries within its data. However, because it can process vast quantities of data, it is able to provide unique insights into the activities which are recorded digitally in cyberspace. It sees numerical correlations and connections within the data which are impossible for humans to see.

Second generation AI algorithms have typically operated on various forms of machine learning: Supervised, unsupervised or reinforcement learning. Each of these is slightly different; supervised learning asks the program what to predict narrowly, unsupervised learning allows the program to classify data itself which reinforced learning specifies the reward. The three techniques are a little different. Yet, in each case, machine learning algorithms have all operated by pure induction. The second generation has developed around deep learning neural networks that allow programs to weigh different bits of data with greater or lesser numerical significance in order to generate a more accurate answer. The more data, the more accurate AI becomes. Second-generation AI knows nothing. However, because there is now

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so much data, it has become increasingly powerful. Its inductions are increasingly accurate that AI can now make sound predictions based on past cases.

The potential of second-generation AI for security and defense purposes is clear. It potentially allows the armed forces to process an unimaginable quantity of data. Because second-generation AI is based on such prodigious quantities of computing power there is almost no limit to the data, it can collate and analyze. It can process data from sources as diverse satellites, ground sensors, and mobile phones to provide an accurate situational picture. AI may allow commanders to see further, more accurately and more quickly across the battlespace. AI may be able to accelerate decision-making.

Given the potential of AI, the prospect of states harnessing AI for military purposes has been the focus of profound professional and scholarly concern. A large and growing literature has already developed which has addressed many aspects of the debate. Many commentators fear that AI will have major global security implications, especially as great power competition between China and the United States intensifies.[6] These discussions are a starting point. However, the primary research question of this article addresses the implications of AI for urban security, and especially for urban operation. Sub questions are how might the application of second-generation AI change the character of urban warfare and how might urban warfare evolve in the next decade as AI becomes ever more potent and ubiquitous?

Supercomputers and Killer Robots

In the light of these dramatic developments, scholars working on global security have become deeply interested by the military application of AI. For instance, in their recent monograph on AI, Ben Buchanan and Andrew Imrie have claimed that AI represents a potentially revolutionary military development.[7] For Buchanan and Imbrie, AI is the new fire. It is the equivalent of ancient Greek fire, or the gunpowder weapons of late medieval Europe. AI will transform the destructive power of weapons. Under AI, lethal autonomous weapons will dominate. AI will enable the rise of killer-robots and swarms of autonomous drones.

It may seem an extreme, even unwarranted, view. The armed forces may soon be able to exploit lethal autonomous systems to monitor, to

strike and to kill their opponents and even civilians at will. In fact, there have already been experiments with autonomous drone swarms. In October 2016, U.S.'s DOD demonstrated a swarm of 103 Perdix micro drones capable of "advanced swarm behaviors such as collective decision-making, adaptive formation flying and self-healing."[8] Clearly, the United States' opponents are attempting to develop this technology. The Chinese have also made significant advances in swarm intelligence. In 2017, a formation of 1000 UAVs flew at Guanghzhou Airshow. In 2017, China Electronic Technology Group flew a 119 fixed wing UAV swarm.[9]

Many scholars have been worried that the armed forces will apply AI-enabled lethal autonomous weapons to urban areas.[10] For instance, the British urban geographer, Stephen Graham descries the proliferation of new security technologies in cities. He believes that the security forces are actively seeking to submit cities to total control. They are apparently obsessed with

> technophilic desire and fetishistic urges for mastery and control, adjusted to the new imperatives of urban counter-insurgency [*sic*] warfare.[11]

AI-enabled autonomous surveillance and weapons systems will enable them to fulfill their ambitions of dominating cities.[12]

Stuart Russell has been a leading figure opposing the proliferation of AI-enabled weapons. He played an important role in the development of AI from the 1980s. As a result, he has campaigned vociferously for the regulation of AI-enabled lethal autonomous weapons. Russell was particularly concerned about the possibility of autonomous swarms of lethal drones and the urban threat they posed. On 12 November 2017, he released a short-film called *Slaughterbots*.[13] The film dramatizes the potential of killer drones which assassinate a senator and invade a university campus. The implication is that once they have been autonomized, humans will lose control of these swarms which will kill without constraint.[14]

In 2020, Stuart Russell gave the BBC Reith Lectures in the United Kingdom. He dedicated one of his talks to the question of the military potential of AI. Once again, he returned to the theme of *Slaughterbots* and killer robots in the urban environment, "All the ingredients to Lethal Autonomous Systems existed in 2015: Autonomous drones, the

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ability to swarm and to be armed."[15] He described a scenario in which a lethal quad copter the size of a jar could be armed with an explosive project device, "A million could be shipped. It is inevitable. The end point is that autonomous systems become cheap selective weapons of mass destruction."[16] He continued, "Anti-personnel mines could wipe out all the males in a city between 16 and 60 or all the Jewish citizens in Israel and unlike nuclear weapons, it would leave the city infrastructure.[17] As evidence, he cited the Turkish recent use of the Khargu-2 autonomous drone in Libya in March 2021. Russell concluded, "There will be 8 million people wondering why you can't give them protection against being hunted down and killed by robots."[18] According to Russell, autonomous armed drone swarms will be clever enough to target cities. Armed drones will be able to identify and kill individual humans–or small groups of them–in streets and buildings.

Other scholars share Russell's vision of the urban threat which AI-enabled autonomous weapons may pose. David Hambling, the drone expert, has described the potential of swarms in urban areas[19]: "A swarm of ten thousand small drones could level a town…A small perching drone could deliver multiple incendiaries the size of bats…Acting together drones might bring down a bridge or skyscraper, but they could do more than that."[20] Similarly, Paul Scharre has claimed,

> Militaries around the globe are racing to deploy robots at sea, on the ground, and in the air- more than ninety countries have drones patrolling their skies. These robots are increasingly autonomous and many are armed. They operate under human control for now, but what happens when a Predator drone has as much autonomy as a Google car?[21]

His anxiety is that "in future wars, machines may make life and death engagement decisions."[22] Ken Payne, the British security studies scholar, predicts the rise of warbots,

> AI systems will allow autonomous decision-making by networked computer agents, enabling extremely rapid sequential action, even in uncertain environments…Soon autonomous and intelligent platforms will be able to maneuver faster, with more precision than those operated by humans.[23]

Soon, the armed forces will be able to dominate cities targeting at will. As a result, many scholars call for a regulation on these weapons, restricting drones to "kill box operations" away from civilians in urban areas.[24]

A consensus is emerging. Soon, AI-enabled autonomous swarms of lethal drones will transform the urban battle. Swarms of drones will fly autonomously over and through urban areas, hunting and killing their enemies with complete efficiency. Sensors will find targets and strike their targets independently of human direction. However, although these authors approach the prospect of autonomous swarms from a different ethical position, their unanimity about the future of urban operations in striking. In the coming decades, the introduction of AI-enabled weaponry will transform urban warfare. Soon, swarms of drones will have substantially replaced human combatants. As a result, the tempo of urban operations will accelerate, the accuracy and simultaneity of strikes will increase; it will become increasingly easy to attack urban areas. Every city will become the potential victim of the autonomous swarm attack, identifying, and destroying their human targets by means of algorithms.

These observers are correct to highlight the importance of second-generation AI to warfare. The development of AI is likely to have profound effects for the conduct of urban war in the coming decades. They have laid out a compelling vision of what that future conflict in cities might look like; swarms of autonomous drones capable of ubiquitous surveillance and guaranteed strike in urban environments will transform military operations in urban areas and urban warfare itself. We are indebted to them. But are they right?

AI and Urban Operations

There is no doubt that remote systems have already become an important part of military operations. Azerbaijan forces used them very successfully during the Second Nagorno-Karabakh War. They have played a vital role in the Russo-Ukraine War. Both sides have employed them ubiquitously in attack and in defense to conduct surveillance and strike missions. Indeed, the Ukrainians are reported expending some 10,000 drones a month. Some of these are loitering munitions, intended for destruction, but the Russians shot down many. Lethal autonomous weapons have existed since the Second World War. Many capable autonomous weapons are currently in use such as, Aegis,

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Patriot, and Israel's Iron Dome, or South Korea's SGR-AI. In the coming decade, lethal autonomous weapons—including drone swarms—will likely appear in greater numbers on the battlefield. It is possible that they might have some impact on urban warfare.

Nevertheless, despite the possibility that in the future AI-enabled autonomous weapons might be deployed routinely on urban operations, the armed forces are a long way from that point now. Robots and drone swarms are unlikely to play a decisive role in urban warfare soon. The environment is too complex,

> In high-intensity and dynamic combat environments such as densely populated urban warfare–even where well-specified goals and standard operating procedures exist–the latitude and adaptability of 'mission command" remains critical, and the functional utility of ML-AI tools for even routine "task orders" (i.e. [*sic*] the opposite of "mission command") problematic.[25]

Even the most successful second-generation AI programs rely on large sets of well-curated data. develop excellent inductive models for stable closed situations. However, because the urban environment is so complex and dynamic, it is difficult to see how a contemporary AI program could learn effectively so that it could execute operations effectively. Moreover, commentators vastly exaggerate the capabilities of drone swarms. In reality, its range and payloads would be limited; a rocket salvo might do far more damage more easily. Advocates ignore the inevitable counter-vailing measures. For instance, in their strategic bombardment of Ukrainian cities with drones and loitering munitions, most airframes were jammed or shot down. The vision of autonomous drone swarms swooping through ruined, burning streets to eliminate targets at will is science fiction, not computer science.

However, just because lethal autonomy is likely to be elusive in urban environments, this does not mean that AI will not be important to future urban operations. On the contrary, AI has already played an important role in urban operations over the last two decades. As the power of AI increases, it seems inevitable that it will become even more important in the next decade. Yet, in the near future of the next decade or so, the primary application of AI is unlikely to be lethal autonomy. Lethal autonomous drone swarms are improbable. As several scholars have already noted, the primary application of AI is likely to be more mundane, but no less important; it is most probable in intelligence.[26]

Second-generation AI processes data on a massive scale. Consequently, it has a paramount ability to analyze a phenomenon and provide insights into it. It is noticeable that recent defense strategy documents have emphasized not lethal autonomy as the primary use of AI, but the way AI may facilitate a transformation even a revolution in military intelligence.[27] AI can be used to process a mass of data so that commanders have a better understanding of the battlespace and are able to plan and target more effectively. Indeed, harnessing vast data sources with the help of AI, military commanders will be able to perceive the urban environment more deeply, more accurately, and faster than ever before. They will be able to identify enemy forces more quickly and precisely. Moreover, even if lethal autonomous swarms do indeed emerge thereafter, they will rely on data to provide them with an intelligence picture of the battlespace. It is useful to provide some examples of this application of AI to urban operations.

Joint Special Operations Command

The armed forces have exploited data and AI with increasing effect for nearly two decades. An increasing number of examples are now available. However, it is useful to go back to one of the earliest employments of data and AI by a western military force in an urban operation. The Joint Special Operations Command's operations in Baghdad between 2004 and 2008 is an obvious example here. In 2004, a Joint Special Operations Command (JSOC) stood up in Baghdad with General Stanley McChrystal as its commander. The mission of JSOC between 2004 and 2008 was the destruction of Al Qaeda in Iraq and the hunt for al-Zarqawi the leader of the organization in Iraq. JSOC instituted an industrial level counterterrorist operation, in which troops mainly from the U.S. Delta Force and the U.K.'s SAS, conducted missions every night against Al Qaeda networks, in Baghdad, Ramadi and Fallujah. They raided houses and bases to kill or capture Al Qaeda terrorists and to acquire intelligence on the networks. It was a remarkable operation and JSOC became a uniquely networked, inter-agency, global organization. It played a key role in the elimination of al-Zarqawi in 2006. Data played an important role.

Early in the campaign, there were several mistakes which underscored the importance of improving their intelligence collection and fusion. For instance, on September 16, 2004, al-Qaida captured the British civil engineer in Baghdad. He was subsequently beheaded by al-

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Zarqawi on October 7, 2004. For three weeks, JSOC were searching for his location, which they failed to find. Yet, retrospectively, it emerged that the evidence was there to locate Bigley; his handler had been identified in JSOC's data, but human analysts missed it, claiming "It was unacceptable then, now even more so."[28] If JSOC had had a more efficient system for combing its data with machine learning, it would have found this evidence and saved Bigley.

To prosecute its campaign, JSOC employed every available intelligence feed. It received intelligence from the Central Intelligence Agency (CIA), National Security Agency, U.K.'s MI6, and other national intelligence agencies. It drew on satellite imagery, signal intelligence, phone-intercepts, open-source intelligence and human intelligence. It was a deluge of information. Many traditional techniques of collation and analysis applied. JSOC was dealing with complicated information and evidence. Consequently, JSOC also applied machine-learning AI to the problem where they could. Many of the intelligence feeds consisted of information which was data or could be rendered as data: That is, quantifiable, computable information. Joint Special Operations Command therefore fused all the intelligence it could into data, to which it applied algorithms to identify patterns and to provide warnings for situations.

Eventually, JSOC brought in several data experts to help. A team from Rhombus Power led by Dr. Anshu Roy played an important role. Roy earned his PhD from the University of Michigan in computing. He invented a patented platform for solid state subatomic particle detection. He has also applied his programming expertise to security problems setting up the company Rhombus Power and building the program Guardian. Rhombus Power is one of the leading tech companies assisting the U.S. DOD in security and defense issues. It has developed algorithms which are able to identify patterns in data which can assist in finding terrorists or enemies.

Roy provided an interesting account of how his team helped JSOC in this process, "There is an order in turbulence. It is possible to discern that order, so that you can intervene in a complex problem."[29] Roy's team took all the data from tactical units and developed an automated system for fusing data from across intelligence sources and analyzing it at speed, "We aggregated and geolocated that data."[30] McChrystal determined the mission and, on that basis, identified his critical information requirements but Rhombus accelerated the solution,

> We mathematized it. We were able to quickly and reiteratively put into a maths [*sic*] construct that could be encoded and put into an AI system.[31]

Using machine-learning and algorithms, Roy's team were able to identify anomalies and signatures in the data, from which they were able to infer about what would happen. Roy's summarized what they had done, "Capture everything you can, mathematize it, encode it so that the next set of people have a far easier time."[32]

The use of data, data analysis, algorithms, and machine learning by JSOC was not a panacea. JSOC succeeded because it had a clear mission and gained a deep understanding of the insurgency in Iraq and al-Qaeda. Human intelligence, signal intelligence, and physical evidence harvested from nightly SOF raids also proved crucial. However, McChrystal's data-centric, AI-enabled method augmented these traditional methods so that JSOC was able to identify Zarqawi in a complex urban environment. The use of big data and machine learning to process it did accelerate the decision cycle and make it more accurate. As McChrystal said,

> As a commander, you check data, then trust it. You develop leaders who know about AI. This information being connected, it makes sense to them.[33]

AI was employed to harness the deluge of information which was in danger of swamping allowed JSOC to follow Zarqawi's digital footprints, correlating them with other evidence. JSOC eventually tracked Zarqawi to a safe-house in a small village called Habib north of Baqubah on 6 June 2006. Two U.S. Air Force F-16 dropped two laser guided bombs on the building, killing Zarqawi and five associates, including his lieutenant.

The Israeli Defense Force

The Israeli Defense Force is equally advanced in its use of data. Since the first Intifada in 1987, the Israeli military's main mission has been to suppress Palestinian terrorist cells in Gaza and the West Bank. Many deplore the political situation in Israel; they describe it, with good evidence, as an apartheid state. However, whatever the political situation, the Israeli Defense Forces (IDF) provides a perspicuous

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example of how data has been employed for urbanized operations. Since the 1980s the IDF has monitored Palestinian groups like Fatah and Hamas closely. In the last fifteen years, it has also explicitly sought to exploit data as a way of tracing and target Palestinian terrorists. Palestinians employ mobile phones for communications which, no matter how many counter-measures they employ, leave a digital signature in cyberspace. In addition to traditional methods of intelligence collection, Israeli sensors saturate the West Bank and Gaza Strip, including satellites, radar, and cameras,

> The data revolution has led to massive amount of operational data being collected [*sic*] from cameras microphones, networks, information systems, and devices. The human factor is no longer sufficient, as soldiers cannot physically keep up with the amount of incoming data.[34]

In addition, Open Source data has become a rich means of collecting intelligence but the amount of potential data it offers is vast. Israeli Defense Officers emphasize the problem: "The data is endless, reaching into petabytes (one million gigabytes) in some areas."[35]

Consequently, the IDF has created several specialist units to harness the potential of data, such as Units 8200 and 9900, J6 or C4I Directorate's Lotem Unit, and the Sigma Branch IDF. As the commander of the Sigma Branch has noted, "the goal is to improve the effectiveness of the IDF." The IDF has trained AI applications to sift through this mass of data to recognize the important information. The IDF's AI programs can analyze hundreds of videos at a time and automatically flag suspicious activity. For instance, after Operation Protective Edge in 2014, a punitive assault upon Hamas in Gaza following rocket strikes, the Lotem Unit developed an app that learned from field sensors and other data, "We collected what are the most likely areas launchers will be set up and at what hours. That enables us to know in advance what will happen and what areas should be attacked in order to fight them more effectively".[36] By 2017, the IDF had already developed sophisticated program of descriptive AI; its algorithms could identify objects on interest in the operating space automatically. The aim was to create predictive AI. AI programs would not only recognize targets for the IDF which were already operating, but also would make predictions about the movements of Palestinian operatives and recommend courses of action.

In 2021, the IDF mounted yet another major operation against Hamas in Gaza, Operation Guardian of the Walls. The Israeli armed forces described the action as the first AI war. Building on the work of its specialist units from 2014, the IDF incorporated AI fully into the targeting process. This was essential because the Israeli's employed a network of electronic sensors on drones, F-35s, seismic monitors and other systems over the course of several years. The IDF had collected billions of pieces of signal and other intelligence on Hamas and the Palestinian Islamic Jihad. The IDF fused these diverse data sets,

> By employing AI algorithms and machine learning, paired with intelligence analysts in 'man machine teams' to flag and review potential targets, the IDF synthesized extensive amounts of data into pre conflict target folders that were significantly more detailed, accurate, and timely than in 2014."[37]

Artificial intelligence allowed for increasingly dynamic targeting, which was also more accurate than in the past. Leveraging data and AI, the IDF developed a system of 'intelligence-drive combat' which disseminated intelligence to combat units in real-time using a digital battlespace management system that matched the targets with precision-guided munitions, "The IDF could conduct highly accurate airstrikes, substantially mitigating risks to civilians."[38]

For instance, during the operation, the Israeli's targeted Muhammed Bawab, the leader of Hamas's east Rafah brigade, who was responsible for abducting two IDF soldiers in 2014. His house was acting as a command post. The IDF wanted to strike the building. However, a variety of feeds—some processed by AI—showed that there were civilians sheltering under a palm tree just outside the house. Shin Bet, the Israeli secret service rang Bawab's neighbors, warning them in Arabic, "You are under the palm tree, near the house. Go away, there's a one-ton bomb coming and you are going to get hurt."[39] Artificial intelligence helped the IDF prosecute a precise lethal campaign, yet civilian casualties were still high: 120 were killed. However, Israel's strikes were certainly more accurate than in the past; 99 confirmed enemy kills, while 40 more deaths may have been enemy. The IDF claimed a 1:1 civilian-to-belligerent casualty ratio.[40] Data and AI had allowed the IDF to target precisely in a complex, dense urban environment.

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Conclusion

In the last two decades, the armed forces have increasingly sought to harness the potential of second-generation AI. Each year, the military potential of AI becomes more apparent and potent. Many scholars, therefore, fear that AI is about to unleash a wave of lethal autonomous weapons which will transform the urban battlespace. Swarms of killer drones will replace human combatants, striking targets in urban areas with remorseless precision and lethality. This article takes an alternative view. AI has become increasingly important for urban operations. However, as the example of JSOC in Baghdad and the IDF show, the real potential of AI lies not in lethal autonomy, but in data processing; and, therefore, in intelligence and targeting. The resources of digital information held in cyberspace, from open sources, satellites, mobile phones, and a panoply of other sensors, potentially provide commanders with an unparalleled oversight across the depth of the battlefield. They can see further and more accurately than ever before. However, to exploit the potential of data, it is essential to employ AI programs to all this material; it is a task which quite defies humans. Data and AI has become a key resource for urban operations; it will become more so in the future.

Both examples involved military operations against terrorists; were lower intensity operations. According to many scholars, the appearance of lethal autonomous drones will accelerate high-intensity combat between states. Battles will become quick, easy, and decisive as swarms fight each other autonomously. Robotized combat will eliminate friction and chaos. This seems highly unlikely. The campaign against Al Qaeda in Iraq was long and hard. Despite its AI-enabled targeting, the IDF are locked into an interminable struggle with Palestinian opponents. Operation Guardian of the Walls may have been precise– but it was not decisive, as the current intervention into Jenin shows.

The Russo-Ukraine War is instructive here. This is a genuine interstate war between two well-equipped forces. With intimate United States support, the Ukrainians have employed a data-centric targeting system that echoes JSOC and the IDF closely. Ukrainian forces have been able to target Russian command posts and logistical hubs to an impressive depth and accuracy by exploiting the power of data and AI-processing. Nevertheless, the fighting in this war has congealed into a series of grueling battles in and around the towns and cities of Ukraine. Sieges,

not lightning maneuvers, have predominated. This pattern will likely continue as the Ukrainians continue their counter-offensive.

The armed forces are increasingly using data to gain a battlefield advantage, but combat, especially in urban areas, has slowed down. The relatively small size of Russian and Ukrainian forces is relevant here; they converge of decisive, often urban locations. Long-range precision artillery and drones have made it difficult for them to move. Data is also crucial. Both sides–and especially the Ukrainians can target accurately and rapidly in the deep. Attritional, positional fighting has therefore predominated. There is an irony today then. With the use of data, forces may indeed now be able to target at the speed of light, but combat operations themselves, especially in urban areas, have slowed to a glacial pace. Twenty-first century warfare has decelerated to the pace of medieval combat.

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