



Immunity and security using holism, ambient intelligence, triangulation, and stigmergy

Sensitivity analysis confronts fake news and COVID-19 using open set transduction

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Abstract

This paper introduces a multi-faceted security methodology based on Holism, Ambient Intelligence, Triangulation, and Stigmergy (HATS) to combat the spread of current pandemics such as fake news and COVID-19. HATS leverages the apparent complementarity and similarity of physical and mental pandemics using adversarial learning and transduction to promote immunity on both using conformal prediction and principled symbiosis. As such, HATS confronts both mental and physical adversity found in misinformation and disinformation. It confers herd immunity using holism and triangulation that call to advantage on sensitivity analysis using open set transduction and meta-reasoning. Ambient intelligence and stigmergy further mediate meta-reasoning and re-identification in building and sharing immunity. As change is constant and everything is fluid, as truth is not always reality and reality is not always truth, and as truth is imponderable and lie can become truth, two things have to happen. First, reconditioning and reconfiguration engage random deficiency to discern familiarity from strangeness and a-typicality. Second, transfer learning using trans-adaptation and transposition, serve adaptation and interoperability. Together, this empowers open set transduction in facing adaptive persistent threats such as deception and denial when it engages moving target defense using modification and de-identification. Immunology and security further come together using to advantage the coupling of active and adversarial learning.

Keywords Adversarial learning · COVID-19 · Fake news · Herd immunity · HATS (Holism · Ambient Intelligence · Triangulation · and Stigmergy) · Transduction

1 Introduction

This paper introduces a multi-faceted immunity and security methodology HATS to combat the spread of pandemics such as fake news and coronavirus COVID-19 infectious diseases. HATS guards and screens out ambush and intrusion, carves and parses adversity and threat, if any, and engages in both evasion and pursuit of attacks. HATS confronts both mental (e.g., misinformation) and physical (e.g., pathogen) adversity and its possible harm that is found in misinformation, penetration, and spoofing. It ultimately confers and shares in herd immunity using holism and triangulation that engage ambient intelligence and stigmergy as all feed on open set

transduction (see Fig. 1 for high level architecture). HATS constantly watches for advanced persistent threats (APT) using proactive defense mechanisms. Furthermore, HATS deploys all-encompassing moving target defense (MTD) mechanisms using principled edits, deidentification and re-identification, and reconfiguration, all tied together to prevent and resolve attacks. Towards such ends autonomic and human-centered computing meet to reinforce and supplement each other. They are driven by curiosity aroused by unexpected and extreme values and become intertwined in discerning the strange from the familiar. As change is constant and everything that flows is fluid, vulnerable surfaces are dynamically shifted to counter denial and deception. Attacks can be deliberate (in pursuit of specific assets and goals) or not (as found in false positives due to misannotation and improper training).

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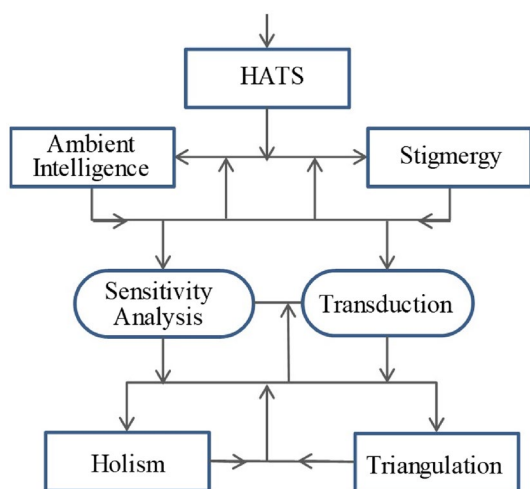


Fig. 1 HATS—holism, ambient intelligence, triangulation, and stigmergy—immunity architecture

HATS contemplates and deliberates using the rudiments of artificial general intelligence (AGI) in coupling causality (see holism) and understanding (see triangulation) while searching for and finding meaning and purpose in experience as it transpires throughout time and place. Expertise such acquired and then learned creates and encodes knowledge bases for future reference and use. This supports passive and active defenses that are shared and serve to induce herd immunity.

As nothing starts from nothing, AGI has the backbone for innate immunity using predispositions on how to adapt and acquire additional and targeted immunity. AGI expands on artificial intelligence (AI) using evidence accumulation and evaluation that is framed and situated using innate and acquired immunity, on one side, reconciliation of apparent contradictions that may arise using critical thinking, on the other side, both sides tied together using reconfiguration and self-organization. This is consistent to falsifiability (see Karl Popper) that claims that the goal of science is to disprove rather than prove conjectures. Towards such ends, both methods cast in terms of representation and reasoning and their processing can be altered to enhance on the ways and means constraint satisfaction problems and decision making are adjudicated. As nothing ever begins when it seems to have begun method and process become aligned to each other to fight adversity, in general, and denial and deception, in particular.

Immunity for the purpose of security, privacy, and trust is the challenge faced here. It is framed as a repertoire of constraint satisfaction problems that are resolved using the machinery of ambient intelligence and stigmergy (see Sect. 5). Such machinery is grounded and situated to discern and void apparent misinformation and its intent, if any, to forecast and reveal the true (foe or friend) identity

of experience and its ultimate purpose, and to evolve principled means to anticipate and forecast better in order to avoid harm and minimize risk. Intent to do something, e.g., misannotate training data, purpose revealed in goals and outcomes yet to be accomplished, e.g., intrusion, and meaning found in the grand scheme of things, e.g., taking over some host and its infrastructure or herd immunity. In addition and consonant to the extent to which this makes for sound foresight, the machinery learns on how to update and upend on common sense and its innate habits while acquiring new instincts and developing intuition that together enrich and expand on overall immunity. Learning is multi-faceted as its strategies and tactics leverage supervised, unsupervised, and self-supervised methods. Transduction lessens the need for big data as estimation is local and bypasses the need for wide open induction and deduction. Last but not least, practical intelligence is responsive to alter the stimulus situation if it need to be so in order to be resolved (Vygotsky (1986)).

The interplay of motivation, computing metaphors, and methods surrounds the human agency and is all-encompassing. Immunity as metaphor permeates all computing. Holism and triangulation confer immunity to adversity and build safeguards to avoid harm using ambient intelligence and stigmergy. Autonomic computing complements human-centered computing to make immunity concrete using transduction and its self-taught tributaries. Reality is not truth and truth is not reality. Fake news, one face of Janus, are not true while bullshit news (Milliere (2020)) are to confuse as they lack in both contents and meaning, if any (see Sect. 4). Immunity, the other face of Janus, is also about misinformation and mischief and how they affect health and well-being (see Sect. 8). As truth is at times imponderable, HATS constantly engages the metaphor of cat and mouse on evasion and pursuit using transfer learning and transposition in coping with both disinformation and impersonation. Form and function meet to vet on how goals and methods are consonant to each other. Transduction pulls the ropes on how evasive and pursuit moves mold and shape the overall security experience and how to best adjudicate all using for good measure context and stratification in confronting malfeasance. The particular domains of application discussed here, those of fake news (and social networks), and infections and pandemics (and public health) find misinformation as their top concern. Fake news (including conspiracy, false advertising, and sentiment analysis) and COVID-19 (both testing and vaccination) make the short list for pandemics and their wild fire spread. As adversity and misinformation underlie all here comes the opportunity to learn from each other and to plan together using multi-task and transfer learning, and transposition. Practical recommendations on how to diagnose and curate adversity and grow and develop immunity are made throughout the paper.

2 Background and Motivation

The method of choice for demarcation, in general, and intrusion detection, in particular, is that of open set transduction (see Sect. 6) using novelty detection. Cohorts, so chosen to trace possible boundary surfaces, can have their annotation and composition altered on demand. Similar to robust statistics, in general, and the random Hough transform (RHT), in particular, accrued evidence is recorded using parameterized (indexed) accumulator arrays. Evidence is constantly accrued and evaluated, interpreted, and adjudicated. The cohorts comport such that their relative strangeness confronts typicality such as familiarity to discern intent and identity and vouch for novelty, if any. There is closed set recognition, e.g., current and valid news, open set transduction that finds for novelty and/or outlier detection, e.g., fake news and infection, and nothing or negative space, e.g., bullshit news where the distribution is uniform and any assignment is possible but yet undetermined. Transduction and its close kin, that of semi-supervised learning, are special cases of unsupervised learning using order and rank. The open set recognition mode springs forth when one of the choices demarcation can make is found to be that of novelty. One can further distinguish novelty from outlier using context and extreme values. Transduction can operate on both singular events and temporal and spatial trajectories of such events. It employs strangeness and typicality, p-values and skew, and credibility and confidence to manage adversity and uncertainty, on one side, and weigh outcomes, on the other side. This comes tied using sensitivity analysis and becomes core to how ambient intelligence and stigmergy are mediated to interface holism and triangulation.

The overall architecture advanced here to achieve herd immunity on misinformation is holistic in nature. The HATS architecture is layered along dimensions aligned to how interpretation and adjudication take place using causality, e.g., holism, and data fusion, e.g., triangulation. HATS allows for both top-down and bottom-up inferences conducive to concept formation and development. Such coupling impacts on (concept) to grow, develop, and evolve. Concepts, both form and function, can dissolve and be forgotten or have their sediments reassembled to better use. Authenticity, relevance, and reputation are revisited and become co-mingled as the connectome that underlies the immunity and security substrate is restructured. There is no fixed and rigid knowledge base or situation graph that holds sway at all times. Towards such ends, holism and triangulation become tuned to each other as they call on transduction and its tributaries to boost their outcomes. Boosting holds sway to some double-entendre. One serves as and adjuvant that enhances the body's immune response

to an antigen, and the other serves transduction for data fusion and triangulation. Alteration to mitigate misalignment and facilitate decision-making goes beyond simple but relevant traits and their edits to makeup for what appears to be lost or missing.

Alteration and transposition using pretraining and transfer learning for fine tuning inform on how to best repurpose what has been observed and experienced (see Sect. 9). Recall Sun Tzu in his subliminal musings on how the coupling of foresight and alteration can serve decision-making. "Bravery without forethought, causes a man to fight blindly and desperately like a mad bull" and "Ponder and deliberate before you make a move." This is where the interplay of holism, sensitivity analysis and transduction, and triangulation using principled cohort alteration mediate ambient intelligence and stigmergy to leverage both past and current experience. Concept formation and development, on one side, and active learning and directed perception advance, on the other side, adjudication. Activities and behavior evolve as their interplay plays out to mitigate risks on fake news and COVID-19. There is ample motivation for this paper as "Falsehoods almost always beat out the truth, penetrating further, faster, and deeper into the social network than accurate information, and "Falsehood flies, and the Truth comes limping after it" (Meyer (2018)). Cyber security confronts trolls and AI bots behind fake news using more of the same. That's a mistake. Social networks are battling complex disinformation with AI-driven bot defenses. But this can only get us so far but not everywhere. Anyone for fact-checkers on fact-checkers?

3 Holism and Triangulation

We motivate here the use of holism and triangulation as security props to address questions on both *what* it takes to develop herd immunity and *why* holism and triangulation together are most suitable to deliver on the goods. Complementary to holism, triangulation seeks for information integration and brings unity to reason over multi-layered evidence and its experience. This section also contrasts holism with reductionism for all-inclusiveness and finds reductionism much lacking compared to holism (Systems Innovation (2016)). Closure on HATS about how holism and triangulation using open set transduction and sensitivity analysis confer immunity and trust using ambient intelligence and stigmergy comes later on (see Sect. 10) once everything about the human agency has been detailed. Holism draws on perspectivism, relationism, and subjectivity to bring unity in adjudication. Triangulation engages holism to make the many alternative but disparate views on evidence coalesce and to make intent and purpose become apparent. Uncertainty, if any, diminishes or even dissolves

as the entropy of the ensemble deemed open decreases using reconditioning and repurposing the evidence found and/or already known.

How do holism and reductionism actually compare against each other? Holism comes first. It follows on Heraclitus to embed the principle of *Panta Rhei*. Change is eternal and everything flows. Holism structures a multi-layer conceptual pyramid that engages stigmergy to reflect on systemic interactions and their dynamics. There are macro and there are micro conceptual layers that are related to each other. Adjudication and interpretation emerge subject to context and environment. What also emerges, grows, and is transformational in nature is systemic complexity. Think of water for an upward (bottom-up) determination for analogy. The water is wet but its components are not. The layers, different in nature, thus confer different explanations that draw on downward causality and triangulation throughout. Method and paradigm precede process and evaluation. The whole has priority over its parts and defines them. Downward (top-down) holistic determination has function and structure explained by the whole while the elementary traits sought after and found by reductionism are superfluous. Holism is active rather than passive and varying perspectives reinforce each other. The systemic human agency seeks immunity to confront adversity and avoid harm. It engages all to make contributions that thread on events as they happen or could have happened using their tentative prequel and possible aftermath.

Holism is also ready made for domain adaptation and transfer learning using pre-training and tuning, on one side, and transposition in both location and function, on the other side. As we are reminded that nothing starts from nothing, some innate and pre-programmed HATS is sculpted using layers of increased complexity such as sensory and phenomenological, cognitive, and social and cultural ones. Redundancy and stratification further shape and reconfigure function, method, and structure for the purpose of interoperability. It all comes to nature and nurture or alternatively prewire and rewire. Reductionism falls short compared to holism in both reach and scope. It embeds the principle of *Ceteris Paribus*, short hand for specific trends all other things (“variables”) being equal. Reductionism believes the world is objective, is static and stays the same, and that it readily reveals itself. There is but one answer and explanation, causality moves upward, and all complexity can be explained using simple interactions between simple traits and their lowest denominator parts that have to still be found. The world and its experience are transparent and thus conducive to empirical inquiry. There is no much place for either context and environment or uncertainty. Truth is immanent and deception and denial are precluded. The world that reductionism envisions is simple and not much aligned with the ways reality makes itself known. Holism, however, knows

that reality is not always what it seems to be and that it can be misleading.

Deception and authenticity play each other as offense and defense wage war. The substrate for the ongoing arms race and redoubts involves associations about resemblance, contiguity, and causation (Morris and Brown (2019)) and their varying cliques that emerge and dissolve. Triangulation builds on associations and cliques to complement on holism and seek that unifying (“adjudication”) view and the fixed point it can be best grasped and seen from. In 1978, “Norman Denzin (UNAIDS (2010)) identified four basic types of triangulation: (I) data triangulation: the use of multiple data sources in a single study; (II) investigator triangulation: the use of multiple investigators/researchers to study a particular phenomenon; (III) theory triangulation: the use of multiple perspectives to interpret the results of a study; and (IV) methodological triangulation: the use of multiple methods to conduct a study.” Examples for each type come next but keep an open mind to the fact that the types may overlap in coverage. Data triangulation or alternatively data fusion is found when multiple sources are identified on the same subject (either on news reporting or COVID-19 testing) and are assessed and/or assimilated using context, reputation, and/or timing. Investigator triangulation is narrower in scope than data triangulation as the data sources are close in reach and scope in expertise and interest. News are disseminated by similar but major social networks, e.g., Facebook and Twitter, rather than by random trolls (users who maliciously provoke others). On COVID-19, the sources are academic or pharmaceutical bound rather than random and maybe politically biased sources notwithstanding the fact that the academic sources may be biased as well. So data fusion depends in both cases not only by reputation and source but by potential, bias that need to be discerned. While the first two types are about data and its source the next two type that of theory (or perspective) triangulation and methodological triangulation are about framing, on one side, and method and algorithm, on the other side. Some philosophy of science such as falsifiability or structuralism, on one side, and ensemble methods such as AdaBoost and random forest, on the other side, are good candidates for use. Here and throughout triangulation is reified over holism. There are many perspectives on data according to observers, the observations made, and the affordances that hold sway. This takes care of investigator triangulation. Perspectives come about both observation and observer. What is observed is faced against how it is observed and interpreted. This comes as theory triangulation and reflects on the coupling of mechanism and structure using calibration and cross-validation (see inductive transduction). Last but not least, methodological triangulation facilitates cross-talk and diversity that seek for coherence, consensus, and consistency using ambient intelligence and stigmergy to mediate the couplings of

holism, re-configuration, sensitivity analysis and transduction, and transfer learning. Such meta-aspects are discussed and situated later on using both quantitative (e.g., reliability indices) and qualitative (e.g., familiar or novel) dimensions.

4 Reality and Truth

Reality is not truth and truth is not reality. At times reality is not what it seems to be and its truth becomes imponderable. Necessity, the mother of invention, however, finds ways and means on how subjectivity and objectivity intersect each other to advantage using alteration, e.g., modification, and triangulation in bringing unity on the views cast using perspectivism. This comes notwithstanding Hans George Gadamer thoughts on *Truth and Method* (Gadamer (2004)) where he rejects as unachievable the goal of objectivity and instead suggests that meaning is created instead through inter-subjective social and cultural communication. Joint attention furthers on inter-subjectivity to hold sway on the relations between people rather than on any solipsistic individual experience where solipsism stands for extreme egocentrism. Truth about the reality behind observation is one but any method by default is subjective as it is loaded with unconscious cognitive biases characteristic of the observer and her tradition. Communicative action is cooperative action undertaken by individuals based upon incentive and preference, on one side, and mutual deliberation and argumentation, on the other side. This engages both the self and crowds using edits and improvisation that draw on joint attention. Collaboration can go beyond problem-solving and decision-making to cover for empathy and sympathy using the likes of mirror neurons whose lack of is thought to be responsible for autism. Note that empathy and empathy make their mark on cognition and augment on its constitution.

We take on both Truth and its Method on how to address ambiguity, meter uncertainty, and avoid harm using sensitivity analysis and triangulation. Truth and Method, seemingly at odds with each another, suggest, however, that meaning (and intent) and truth (and understanding) are created through hermeneutics and inter-subjective (social rather than solipsistic) communication. There is daylight between the development of abstract concepts brought about using instruction. Abstraction comes first and the development of concrete heuristics or street smarts comes second and builds upon what has preceded using scaffolding (Vygotsky (1986)). Truth and Method meet and are only temporarily resolved as original intent, unconscious bias (see again Hans George Gadamer), embodiment, transduction, and holism and triangulation become all intertwined to make together the case for how to interpret a “historically” affected subjective experience. Historically, because nothing actually

happens when it seemed to have happened. The subjective experience further reflects on reality not the way it is but rather the way we can observe and assimilate it. The same unconscious bias revisited. Reliance on too much data and nowadays on Big Data to boot, can, however, hinder and obscure what to contemplate and deliberate on and how.

What to actually contemplate and deliberate on instead? Much but for illustration here only some highlights. Correlation is not causality so aim for the second instead including confounding (“instrumental”) variables for good measure. In statistics, a confounder is a variable that impacts both the dependent (“effect”) variable and independent (“causative”) variable, causing a spurious association. Instrumental variable such as the weather did find that childhood TV viewing may trigger autism something that data analysis would confirm. Confounding, a causal concept, cannot be described in terms of correlations or associations. There are many illuminating paradoxes about the pitfalls waiting for triangulation. One of them, the Simpson paradox,¹ finds that a trend can appear in several different groups of data but disappears or reverses when these groups are combined. As uncertainty and truth are imponderables and as there are known knowns and unknowns, on one side, and unknown unknowns, on the other side (be tuned to Donald Rumsfeld) it is important to equivocate, punt, and hedge on truth. Instrumental variables hidden from sight are just one example of unknown unknowns. As lie at times becomes truth their history should be documented and treated as such to reveal and leverage on hidden influence and arbitrage disputation, if any.

Cognitive biases, conscious or not, mediate between reality and truth. They are human tendencies that can lead to systematic deviations from accepted standards of rationality and as such they are often studied in psychology and behavioral economics. Such biases are grouped by some into four main categories: biases arising from too much information, not enough meaning, need for fast response, and bounds and limitations posed by memory bandwidth. Examples of biases include anchoring (e.g., focus on one trait) and attention bias (e.g., focus on preponderance of information), base rate fallacy (e.g., ignore base rate information) that affects intrusion detection (e.g., seeking for a needle in a haystack), confirmation bias (e.g., the tendency to search for information that confirms prior beliefs), hyperbolic discounting (e.g., display stronger preference for payoffs made sooner rather than later), and last but not least, asymmetric risk aversion (see prospect theory) where loss hurts more than gains missed.

¹ https://en.wikipedia.org/wiki/Simpson%27s_paradox.

5 Ambient Intelligence and Stigmergy

Humans constantly make decisions and act on them. This what the human agency does 24/7. Of particular interest herein is the ability to enforce security, privacy, and trust protocols that ensure that human-centered computing is reliable and robust. Complementary but similar to human-centered computing is our well being notwithstanding pathogens and their blow-up in pandemics. Mental and physical are tied together to search for and develop herd immunity over the space that the human agency holds sway on. Adversity is also found in both fake news and bullshit news. Fake news is false information delivered under the pretense of it being true. According to Harry Frankfurt (Milliere (2020)), “bullshit is speech intended to persuade without regard for truth”. In that sense, there is an important difference between a liar and a bullshitter: The liar does care about the truth insofar as they want to hide it, whereas the bullshitter only cares about persuading their listener. Importantly, this does not entail that bullshitters never tell the truth; in fact, good bullshitters seamlessly weave accurate and inaccurate information together. For this very reason, as Frankfurt puts it, “Bullshit is a greater enemy of truth than lies are.” Once prompted, the generative language GPT-3 application was compelled to complete the first sentence of Frankfurt’s essay (see above). Here is one of the several outputs it came up with: “Bullshitting is not always wrong, though sometimes it can be harmful. But even when it is harmless, it still has some serious consequences. One of those consequences is that it prevents people from being able to distinguish between what’s real and what isn’t.” That’s more bullshit, of course; but it fittingly rings true (Milliere (2020)). Bullshit and post-modernism go hand in hand to argue that there is no objective truth. It thus become imperative that both fake news and bullshit are found and marked as such and that immunity against both be developed.

Ambient intelligence mediates an immediate physical and/or mental infrastructure and its surroundings when such adversity as described above does occur. Ambient intelligence seeks to accrue and evaluate multi-faceted information about possible attacks and threats affecting the physical and mental bodies of the human agency. Ambient intelligence works its charms in many ways including holism and triangulation, introduced earlier, transduction discussed in the next section, and stigmergy addressed here. Stigmergy ties together enactivism and coordination. Enactivism places claims on the cognitive dimension of the human agency using its dynamic interaction with both its physical environment and the surrounding social milieu. Coordination between agents and their actions take place within the ecosystems where human-centered computing takes place. The

cat and mouse principle involved here is that offense and defense stimulate each other on how to act next.

Curiosity, which is aroused by expectations not met and/or extreme values found, drives exploration and exploitation to advance goals and objectives such as intrusion detection (see Sect. 7) and spoofing. Perception drives control and anticipation. Their couplings are fodder for reinforcement learning possibly using adaptive heuristic critic and/or A/B trial and error testing. As everything is fluid and subject to change, logistics are better managed on the behalf of the human agency using active and directed perception to focus attention and lock on objects and events. Last but not least, stigmergy harnesses such mechanism to address adversarial learning and to preempt the possibility of training using mis-annotation by erecting redoubts that make offense onerous. Observer and observation meet to find meaning and purpose and control how to best engage each other and to what advantage. Monitor to maintain and sustain and regulate to control and anticipate. The rubber meets the road to the extent to which ambient intelligence and stigmergy are well integrated and reinforce each other around attention.

As the boundary between mind and machine is porous particular emphasis is placed on what are the break-down points in behavior and performance and how to have them edited using framing and throwness. Frame on meta-knowledge using throwness to leverage ambiance and context. One way to conceptualize accurate and adaptable response using the full force of stigmergy is that of “stimulation of agents by the performance [including evocation] they have achieved”.² Stigmergy explains “what had appeared to be paradoxical when in an insect, society individuals work as if they were alone while their collective activities appear to be coordinated.” Even that (macro-molecular) collective cognition is indirect it complements to advantage micro-state and individual agents to springboard overall swarm coordination Cumulative cultural evolution (CCE), the driving force behind cumulative technological culture (CTC), argues that only humans teaming together can accumulate modifications that come over time and that such modifications come as unitary phenomena. The ratchet effect would have it that effective modifications take place without reverting back to prior but less effective states. Stasis, if any, is only temporary. This explains how herd immunity emerges, grows, and develops to be shared and further evolve. Last but not least, stigmergy reshapes meaning as it is flexible on purpose using transadaptation and transposition (see Sect. 9).

² See Pierre–Paul Grasse, <https://doi.org/10.1162/106454699568700>, 1959.

6 Semi-supervised Learning Using Transduction

Different from induction and deduction, semi-supervised learning and transduction are closely related. They deal with both labeled and unlabeled instances – this explains the etymology of semi-supervision – in seeking to reach consensus on proper annotation labeling and on how to act best and behave according to the demarcation found. Open set transduction (Li and Wechsler (2005)) discerns the atypical as not familiar and strange from the typical and familiar. Non-familiar cases can show up due to errors in annotation, exceptions or outliers, and last but not least due to novelty. There is always the reject option Don't Know that meta-learning treats to advantage using stratification and triangulation. The closed set case treats all the cases encountered using nearest neighbors majority voting and the smoothness assumption (see next) to label all cases including atypical ones. Towards such ends, both semi-supervised learning (SSL) and transduction leverage the *smoothness assumption*, characteristic of supervised learning, where similar examples share similar labels; the *cluster assumption*, where samples in the same cluster are likely to be of the same class; and the *low-density separation assumption*, to seek for decision boundaries in low-density regions. All such assumptions are principled enough to also distinguish non-familiar cases either as novel categories or as outliers coming from some known class. One can hedge to make more than one designation to each case found atypical or not.

Self-supervision further expands on semi-supervised and unsupervised learning using innate or acquired immunity to parse and interpret an augmented reality and its experience that holds the potential to be offensive in nature. Such augmentation employs some joint embedding of sensory impression and normative (“behavioral”) description. Transduction, using both strangeness (see below) or typicality, meters for extreme values or surprise. It further orders and ranks how strange instances are relative to each other. Taken together, this mediates the coupling of compression and regularity using p-values and randomness deficiency to find for novelty or outlier detection. Demarcation margin, ranking, p-values and randomness deficiency, and minimum description length (MDL) augment the prediction outcomes using reliability indices such as credibility and confidence in order to carry out sensitivity analysis. Prediction is thus not bare but rather endowed with belief and trust to carry out sensitivity analysis. This focuses attention and provides guidance on how to narrow down on ambiguity and uncertainty for calibration and validation purposes.

Learning plays a fundamental role to balance internal representations and external regularities (Edelman

(1987)). Minimum description length and regularity meter for coherence and conformity using randomness deficiency and Kolmogorov complexity. The larger the randomness deficiency is the more regular and more probable its corresponding event or pattern is. Transduction thus chooses from all possible putative labels the one that yields the largest randomness deficiency. Towards that end, one engages randomness and complexity control using similarity and rankings driven by strangeness and p-values. The strangeness, characteristic of non-conformity measures (NCM), measures the lack of typicality with respect to its true or putative (assumed) identity label and the labels for all the other instances and patterns known. The strangeness α is the (likelihood) ratio (“odds”) of the sum of the K nearest neighbor (KNN) similarity distances d from the same class y divided by the sum of the KNN distances from all the other (not y) classes. The smaller the strangeness, the larger its typicality and the more probable its (putative) label y is. One finds empirically that the strangeness, classification margin, sample and hypothesis margin, near miss, posteriors, and odds are all related via a monotonically non-decreasing function where a small strangeness corresponding to a large margin. The likelihood like definitions for strangeness are intimately related to those used to advantage by discriminative rather than generative methods.

Complementary to strangeness, the p-values compare (“rank”) the individual strangeness values to determine and rank the credibility (“accuracy”) and confidence (“ambiguity”) in the putative classifications made. The p-values aggregate information on the relative strangeness indices and inform on the degree of typicality found. The p-values bear resemblance to their counterparts from statistics but are not the same. They are derived using the relative rankings of putative classifications against each one of the classes known. The standard p-value construction, where m is the cardinality of the training set T , constitutes a valid randomness (deficiency) test approximation for some edited but putative label y assigned to a new pattern z . Edits are not restricted only to labels but can also engage both cohort composition and hints about how to best alter the very representation of the objects and/or events of interest. The p-value is defined as the number of known patterns whose strangeness is greater than the strangeness of z divided by $m + 1$ where m is the number of classes (“labels”) known. The p-values assess the extent to which data supports or discredits the null hypothesis for each putative label. The largest p-value found defines the credibility of that putative classification chosen, i.e., all the other alternative classification labels are stranger and thus more atypical.

Demarcation, using the transduction confidence machine (TCM), chooses for classification that label that is most

consistent with the current training set. The label found is indexed by the highest p-value, i.e., it is most typical and least strange. The intuition behind TCM is to best model any instance using the SSL assumptions enunciated earlier while changing the original (predictive) model learned as little as possible. If it ain't broke don't fix it. The confidence measure is the difference between the top two p-values. It indicates how close to each other in credibility the first two classification labels are and it thus meters for ambiguity and uncertainty. The larger the confidence the smaller the ambiguity is. The ambiguity drives structured prediction (e.g., multi-task learning) and triangulation. The credibility and confidence indices are conducive to active learning, information fusion and triangulation, decision-making (e.g., classification), and meta-reasoning. We illustrate next how open set transduction can build adaptive Oracles for recognition, in general, and intrusion detection, in particular, and how they can then withstand obfuscation to distinguish outlier cases from unfamiliar or novel ones. Note for edification that transduction is aligned in spirit with discriminative methods in choosing cohorts and in using non-conformity measures (NCM) for local estimation of likelihood ratios.

7 Intrusion Detection Using Open Set Transduction

Immunity, notwithstanding its nature, innate or acquired, delivers first on constant and timely screening suitable for intrusion detection, second on transfer learning and transposition using distillation and re-configuration, and last but not least on curation using triangulation. Distillation comes first on compression for better comprehension using self-organization and vector quantization and second on holism and relationism using cross-talk and disputation. Detection separates wheat (information) from chaff (misinformation and disinformation). Active learning or structural filtering holds sway throughout in shaping the course and structure of training and validation, on one side, and directed perception and importance sampling using query by transduction (Ho and Wechsler (2008)), on the other side. Vulnerabilities are many and each one of them affects immunity and security differently. As an example, functional creep affects interoperability. It occurs when information varies if and when used across different platforms.

Holism and triangulation are staged step wise as they use transduction and its tributaries to screen and detect intrusions, avoid harm and misinformation, and be smart on how to best deploy defenses and be conducive to artificial and natural immunity. The intrusion detection aspect is discussed here, while the particulars on immunity including architecture, strategy, tactics, and vaccination [sic] are deferred to the next section. While TCM delivers on closed

set recognition, it does not address, however, open set recognition, where one still needs to quantify the degree to which something can be found strange enough to be rejected as novel and unfamiliar. Towards that end, one expands on TCM to define TCM-R (with R standing for detection and re-identification). Detection and rejection are now available to make open set recognition whole. Impersonation and spoofing are now subjects for detection. The question TCM-R has to answer now is when to exercise the reject option for such non-self detection purposes. The challenge is that one knows only how to model the “normal” class and its outliers using for analogy one-class classification problems. Note that R above (see TCM-R) is two pronged as categorization or recognition applies to both detection and identification and with a reject option available in both cases. Detection finds attacks and issues alerts while identification distinguishes the type of attack, say impersonation or spoofing.

The approach pursued by TCM-R distinguishes between individual strangeness and (“context aware”) p-values, when some outlier, still within range and not much different from the “self,” is found not necessarily atypical compared to alternative putative classifications for which the non-self and novel (e.g., carrying alternative putative label) patterns would yield smaller p-values and are duly rejected. One-way to determine the thresholds needed for rejection is to re-label each self-pattern as non-self, derive the corresponding p-values distribution under such a false assumption, and then empirically determine a suitable threshold that demarcates self from non-self (Li and Wechsler (2005)). Towards that end, one re-labels the training samples, one at a time, with all putative labels except the one originally assigned to it. The PSR (peak-to-side) ratio, $PSR = (p_{max} - p_{min}) / p_{sidev}$, records the resulting p-value distribution and determines, using cross validation, the [a priori] threshold used for self-authentication. The PSR values found are low because their relative strangeness is high (and p-value low). The threshold used is empirically chosen to be several standard deviations away from the PSR mean. The PSR distribution derived in such a manner supports negative identification (e.g., negative selection).

Active and adversarial learning are intertwined to spring forth efficacy and effectiveness. Both of them are charted to show due diligence in order to focus on what is most useful and save on resources spent, on one side, and deploy safeguards suitable to avoid harm and obfuscation, on the other side. They are engaged using reactive and/or proactive modes of operation. In the reactive mode, the offensive side engages in attacks while the defense is limited to analyze the attacks and to develop countermeasures. The proactive case learns from past as it seeks to better forecast and protect. The defense now gets more involved as it models the adversary,

simulates attacks, evaluates attacks' impact, develops countermeasures, and raises better defenses for redoubts.

One possible taxonomy for adversarial learning that impacts on intrusion detection takes place along three axes: influence (exploratory/reconnaissance or causative), specificity (targeted or indiscriminate), and security violation (integrity, availability, or privacy). The particulars of adversarial learning are primed by meta-recognition to distinguish between different attacking behaviors, where are they likely to be encountered, and for what purpose (e.g., advertising and marketing, sentiment analysis, and infection). The persistent arms race between defense and offense brings up continuous trade-offs on triangulation between reverse engineering where the attackers want to divine the Oracle used by defense and/or compromise it and hot spots and randomization schemes used by defense to confuse the attackers.

As part of the intrusion detection and re-identification process, HATS engages martingales (Ho and Wechsler (2010)) on transduction outcomes to address covariate shift, e.g., changes in the data distributions characteristic of the arm race encountered during cat and mouse evasion and pursuit, on one side, and change and drift detection, on the other side.

8 Natural Immunity

This section is on immunity and Immunology. The observation that the aims of biological immune system (BIS) and information detection systems (IDS) are functionally similar is not new. This has led to the design of artificial immune systems (AIS) that interface between BIS and IDS using concepts borrowed from natural genetic engineering, in general, and evolutionary computation (EC) and genetic algorithms (GA), in particular. AIS can provide a high level of protection from both invading pathogens [but at times can still fail] and misinformation. As the pathogens assume both physical and mental identity, e.g., COVID-19 and fake news, AIS can be also of help with recommender systems and with security attacks in software-defined networks (SDN). Natural immunity is discussed next, while its impact on HATS is discussed in the next section.

The immune system is a host defense system that distinguishes the self from non-self and protects against infection caused by invading microbe or pathogen. Host and infection generalize to herd and pandemic particularly when social-distancing is not observed. Both physical pathogens like viruses and mental ones like social postings and tweets are harmful. They should be screened for and once detected be removed or at least protected from. There is an innate immune system and there is an adaptive immune system. Everything on immunity has to start from something and this

is the role of the innate system. Adaptive ("acquired") immunity becomes necessary when the innate system falls short on infections. It occurs after exposure to an antigen either from a pathogen or vaccination. It further requires memory to become responsive on future encounters. There is also a blood-brain barrier that separates the peripheral immune system from the neural immune system something that suggests gating and stratification. Pathogens fight the immune system as they evolve and adapt, while the immune system evolves and adapts as well. Evasion and pursuit, intertwined in a constant arm race where hosts and invaders fight each other, hold sway in both defense and offense. Immunity can be either active to generate antibodies in response to natural infection or in response to artificial infection of antigens that occurs during vaccination, or be passive and lasting less as it draws antibodies from other organisms and bodies. Innate immunity, if any, acts fast. Adaptive immunity takes times to develop and be active. Both innate and adaptive immunity can be life long or if time limited need additional boosting. Herd immunity can spread both the natural ("contact") and artificial ("vaccination") way using either contact, straight infection, and/or vaccination.

One can elaborate further on the mode, source, and timing of immunity. One way for innate immunity to operate is by recruiting immune cells at infection sites using mediators such as cytokines. Too much of immunity is never good as inflammation and overreaction do occur to create a cytokine storm that can be fatal. Clinical immunity, inflammation, and intervention are intertwined in COVID-19 to affect the "identification and rational design of effective therapies" (Tay et al. (2020)). The major cellular component cells involved in the adaptive branch of the immune system are the *B* and *T* cells. The (white) *B* cells can recognize surface antigens and accordingly generate antibodies, while the *T* cells can only recognize antigens outside the infected cells. *Divide et Impera*. The *T* cells make up and regulate the adaptive immune system. They kill infected cells, activate immune cells, and produce cytokines. Some *B* and *T* cells are retained to be reactivated if infection recurs. Immunity can be only short-lived if new strains occur and/or memory fades away. There is thus susceptibility to reinfection and more than one dose may be needed to boost the vaccine. As thresholds between positives and negatives using the polymerase chain reaction test are still arbitrary there is no agreement on the extent to which a prior infection guarantees long-term immunity (Toy and Stancati (2020)). Antibody tests are more likely to underestimate than overestimate the number of coronavirus infections, as some infections are milder than others and depend on the strain encountered.

As coronaviruses can assume more than one form, infection with severe acute respiratory syndrome (SARS) should aid in developing immunity to COVID-19. Holism and triangulation harness what is inherited and shared by such

infections in exposed individuals using cross-reactivity, neural group selection, and predisposition (Edelman and Tsoni (2001)) rather than start from scratch to generate antibodies in unexposed individuals. Antibodies are proteins once they recognize the virus they bind to it and neutralize it. This confers immunity that becomes faster and stronger if the same pathogens were to reoccur. “Synthesized bits of the virus were found to mobilize white blood cells known as helper T cells that coordinate a broad immune response to the infection and activate B cells. A second type of T-cells that seek out and destroys cells hijacked by the virus was detected in most [exposed] subjects” (Grifoni et al. (2020)). Similar but much less T-cells were found in subjects not infected but could have come down with SARS in the past. The emerging theory is then that “exposure to other coronaviruses earlier in life helps some individuals fight the new invader.” This lowers the threshold for herd immunity and may explain why the course of the disease and its severity can vary. “An outside possibility is that the reaction might even worsen the illness, perhaps by tricking the body into thinking the new coronavirus was a harmless cold.” Detection of the spike protein characteristic of the COVID-19 virus while obviously provides incipient protection is time dependent and for how long immunity is retained remains to be determined.

9 Adversarial Learning and Sensitivity Analysis

Categorization starts with detection. It engages transduction in a cat and mouse game of evasion and pursuit. Hot spots are set up and active authentication comes alive using adaptive and moving target defense and reconfiguration. It all comes to total war between defense and offense. Sun Tzu (Tzu (1988)) finds that all warfare is based on deception [but denial is also a strategy of choice]. “Hence, when we are able to attack, we must seem unable; when using our forces, we must appear inactive; when we are near, we must make the enemy believe we are far away; when far away, we must make him believe we are near. Pursuit is constant and so is evasion as near capture and repeated escape happen.” Moving target defense leverages stratification and transfer learning, on one side, and transposition and triangulation, on the other side. *Divide and Impera* using stratification and pre-train and tune using transfer learning. Multi-task learning, complementary to transfer learning, engages assembly and composition when either form, function and/or structure are found useful to share. Transposition and triangulation leverage holism to recondition and repurpose events and patterns using edits and hints, on one side, and an altered function or location, on the other side. Transposition alters location, while transadaptation alters function. Both transposition and transadaptation assist with transfer learning and can co-exist.

The coupling of robust statistics and triangulation, cast and shaped using the robust Hough transform (RHT), randomly samples instances and edits their apparent appearance and behavior, and aggregates and demarcates on outcomes according to relative coherence and belief strength. Transduction fights deception as its methods and those of transfer learning and transposition are tuned to each other.

Sensitivity analysis and triangulation spring forth active and adversarial learning, on one side, and attention and directed perception to focus on what is intriguing and salient, on the other side. All in all sensitivity analysis finds intent and purpose and the ways and means behind them. Towards such ends, active learning and directed perception lock on affordances that can close the recognition loop. using relevance and reputation. Relevance to discern friend from foe, and reputation to outflank bias and mal-intent. The adversary undermines redoubts using denial and deception to evade detection and deceive defenses. The motivation behind active learning comes from the need for promptness and selectivity in separating (e.g., filtering) informative contents from obfuscation using limited resources. This involves what is best to annotate (e.g., events of interest) and when, the annotation process itself (e.g., the Oracle), and countering what are perceived to be potential vulnerabilities (e.g., to compromise the Oracle). Such concerns taken together affect how learning and training ultimately mediate intrusion detection, the reputation of the shibboleths involved (see social network analysis), and their principled and successful overall resolution on how to combat harm and overcome misinformation.

Vulnerabilities, known and unknown, are many. They affect both relevance and reputation. Each of them affects on immunity differently according to functional creep, interoperability, if any, platforms, and privacy. Transfer learning and transposition make all whole or almost whole using holism and triangulation. Vulnerabilities occur once attacks become different from those the defense has been trained on. Note that even the training data itself is subject to attacks and can be disturbed. Fight fire with fire. Make sure that deception and denial hold sway on both the defense and offense fronts. Defense at its best entails offense. One vulnerability, that of insider threat, suggests that information be parcelled and that major decisions are better invoked and made by committees. HATS, all-encompassing to account for varying vulnerabilities, brings all under one roof. Everything now flows and change is constant using edits and principled modification. HATS expands on active learning to further leverage perceived adversity using relevance and reputation sampling. This is done using RANSAC to iteratively seek for random sample consensus on adversarial data with novelty accounted for using open set transduction and outliers discounted. The Random-Hough Transform

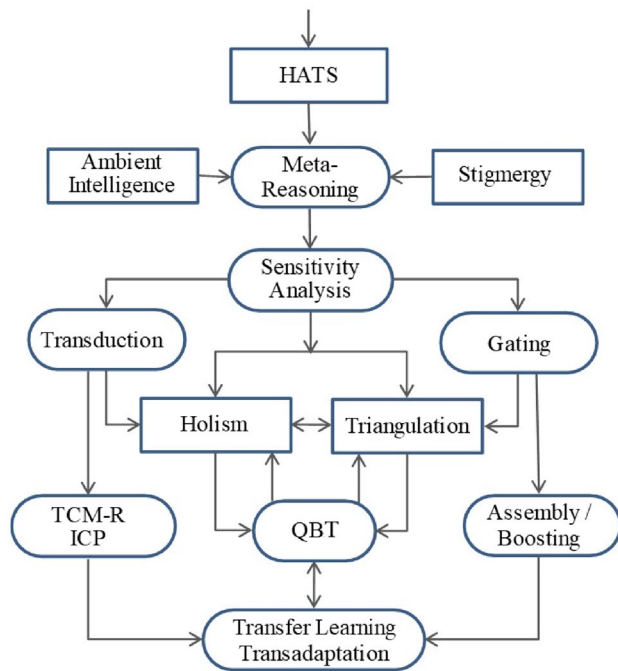


Fig. 2 Sensitivity Analysis Confronts Fake News and COVID-19 Using Transduction and Gating

(RHT), parameterized and indexed to factor in what can make vulnerabilities occur, complements on RANSAC in metering and aggregating contributions that are currently experienced and in assigning credit and responsibility to what would ultimately be found to influence and support attacks. Aggregation is traced, cause for intrusion, if any, is found, and alerts on intrusion detection are issued.

In light of the above, adversarial learning (DeBarr et al. (2013)) addresses misannotation, deliberate or not, as it is detailed next. RANSAC starts with a small but randomly chosen data set of instances and estimates some parametric model that fits data best. It then iteratively enlarges the set with consistent data, when possible, and re-estimates the intrusion model and its error. Coherence about demarcation is sought throughout using support vector machines (SVM) as principled modifications are made to challenge objectivity and truth in annotation. Starting from different subsets, RHT-SVM leverages multiple versions of the decision boundary to identify events and messages that have been mislabeled deliberately as a result of persistent attacks, or not and due to poor Oracle annotation. The RHT-SVM uses the product of the actual classification label and the average signed distance of an observation from the decision boundary to determine if a training event has been mislabeled. The labels for messages, which on the average appear on the wrong side of the boundary, are flipped and a final SVM model is trained using the modified data. This expands on an agnostic active (A^2) that maintains both a current version

space and a region of uncertainty. It is not only labels that can be reconditioned, here flipped, but also the instances themselves can be reconditioned using educated hints and random edits.

10 Boosting and Conformal Prediction

HATS has been introduced earlier. It meets the management and logistics needs of the human agency on immunity both physical and mental. It integrates representation using holism, inference using triangulation, and control using sensitivity analysis and transduction (see Fig. 2). Sensitivity analysis finds intent and purpose using transduction, in general, and query by transduction, in particular. Overall management comes courtesy of ambient intelligence that ties together information and intelligence and have them reflect on each other. The logistics are about stigmergy where bodies and organisms interact with each other including their surrounds and social milieu in order to face adversity and avoid harm. Above and beyond all, HATS learns and can reminisce about timed past experience and its valence. Gating and interaction are the province of meta-planning and meta-reasoning. It engages open set transduction, transfer learning and transadaptation, and their principled composition using assembly and boosting (see Wechsler and Toor, 2018, for particular use of boosting on face detection). This makes for better forecast and it decreases ambiguity and uncertainty. Sensitivity analysis calls on gating to leverage on any misalignment found between what is expected and what is experienced, on one side, and extreme values that arouse enough curiosity to be further explored and exploited, on the other side. Additional misalignment can be found in how the familiar and the atypical meet each other. It is resolved using innovation and novelty and it is conducive to concept formation and development. It also finds for misalignment as misinformation or outliers.

The motivation for meta-reasoning [including meta-planning] can be traced to Marvin Minsky and Levin Kanal, who have claimed that “It is time to stop arguing over what is best [for decision-making] because that depends on context and goal. Instead we should work at a higher level of [information] organization, [e.g., holism] and manage [e.g., triangulation] the logistics on how to build and evade the different limitations of each of these ways of comparing things” and that “No single model exists for all pattern recognition problems and no single technique is applicable for all problems. Rather what we have in pattern recognition is a bag of tools and a bag of problems,” respectively. This is prima facie to account for cross-reactivity and cross-talk using the coupling of clustering and selection, on one side, and triangulation, on the other side. As everything is both fluid and rich, there are diverse streams of computation with

B and T cells on call and responsive to build defense lines that fulfill different but complementary roles. Such streams, the result of gating using meta-reasoning, are the province of decision forests that expand on random forests. Decision-making holds sway but at a higher layer of abstraction (see holism) and as an add-on that engages and tops on classification. Pragmatic and constructive context-aware information fusion (see triangulation) supports reliable active learning for intrusion detection and re-identification using conformal prediction and inductive transduction (see below) and consensus reasoning.

Aggregation and stratification are intertwined to further combine and deploy expertise using gating and triangulation. Gating holds sway on the likes of ensemble of methods and mixtures of experts. Boosting together with transduction build substrate for gating. It sharpens expertise on immunology and it also plays the role of an adjuvant that impacts on how vaccination strengthens on immunity itself. Core to immunity using meta-recognition is re-identification, a process that adjudicates if events currently experienced have been already seen in the past and would leverage on determination made then. Re-identification builds the substrate for incremental rather than one – shot learning. It is charted on using negative and positive selection, on one side, and clonal selection, on the other side. Carve and parse to find traits that reveal attributes and parts using SSL assumptions now charted to authenticate, interpret, and re-identify events of interest across both time and space. The strangeness mediates how coupling such traits (“weak learners”) and boosting construct the substrate of filter and wrapper classification and recognition methods. There is a soup of information and methods and it is up to ambient intelligence to now leverage on sensitivity analysis. Ambient intelligence chooses and mediates meta-reasoning using principled gating. It makes the best out of tributaries serving holism and triangulation and boosts [sic] overall immunity.

The coefficients of the weak learners and the thresholds that transfer to open set recognition and rejection (“novelty detection”) are learned using validation events and their patterns (Li and Wechsler (2009)). The best feature correspondence for each component is sought between validation and training patterns over existing components. The strangeness of the best component found during training is computed for each validation pattern under all its putative class labels c ($c = 1, \dots, C$). Assuming M validation pattern from each class, one derives M positive strangeness values for each class c , and $M(C - 1)$ negative strangeness values. The positive and negative strangeness values correspond to the case when the putative label of the validation and training pattern are the same or not, respectively. The strangeness values are ranked for all the components available, and the best weak learner h_v is the one that maximizes the recognition rate over the whole set of validation patterns V for some component

i and threshold θ_i . Boosting is similar to cascade classification as on each iteration another weak learner component is chosen. The level of significance α (not to be confused with the strangeness α) determines the scope for the null hypothesis H_0 . Different but specific alternatives can be used to minimize Type II errors or equivalently to maximize the power $(1 - \beta)$ of the weak learner. During cascade learning each weak learner (“classifier”) is trained to achieve some (minimum acceptable) hit rate $h = (1 - \beta)$ and (maximum acceptable) false alarm rate α . Upon completion, boosting yields the strong classifier $H(x)$, which is a collection of discriminative components h_i . The hit rate after V iterations is h^V , while the false alarm is α^V .

We introduced in prior sections transduction and some of its tributaries, TCM-R using strangeness and p-values and active learning using QBT. We now outline how gambling [sic] can equivocate, hedge, and punt, on one side, and calibrate and validate, on the other side, to use to advantage principled choice for triangulation purposes. The reliability indices introduced earlier are well-calibrated (see below). They are generated assuming only that data are generated independently by the same (but unknown) probability distribution, a standard assumption in machine learning that can be, however, relaxed. The credibility index is *well calibrated* (or conservatively valid) to ensure that the frequency of prediction errors does not exceed t (between 0 and 1) at each confidence level $1 - t$ (in the long run). Smaller values of t provide greater belief and trust. The confidence measure, which expresses the extent of ambiguity, becomes *efficient* as prediction (nested) sets (regions) Γ shrink (in terms of the number of possible outcomes) with the prediction regions becoming as small as possible. As an example, the inductive conformal (transductive) predictor (ICP), characteristic of incremental and open set recognition using transduction, maps a (labeled) data sequence (training set) T and a new data sample x as

$$\Gamma^t(T, x) = \{y \in Y : p_y > t\} \quad (1)$$

with $\Gamma^{t1} \subseteq \Gamma^{t2}$ for $0 \leq t1 \leq t2 \leq 1$. Empty predictions correspond to impersonation, e.g., spoofing, and are rejected. Empty predictions indicate lack of familiarity and call for their outright rejection. Triangulation iterates on ICP seeking some fixed point or alternatively becomes efficient in finding the smallest (in ambiguity) prediction region (Vovk et al. (2005)). Holism and triangulation are tied together to combine the laws of the individual to those of the collection (see stigmergy) using conformal prediction for efficacy purposes.

Adults are afflicted by many biases (see Sect. 4). Babies, however, seem to avoid the confirmation bias trap. They show curiosity and are “hungry” for novelty. The babies are found to seek for those facts that falsify their current mental

models and gain them deeper [sic] understanding about how the surrounding world works. This is consonant with how science evolves using falsifiability. Surprise enhances adaptation, leads to further exploration, and impacts on active learning and directed perception. Choosing what to learn and from whom and what to ignore. It has been shown that 11-month-old infants used violations of prior expectations as an opportunity for further exploration, in making new conjectures, and have them then tested (Stahl and Feigenson (2015)). We can and should thus follow up on how children grow and develop not at once but over time and how they use to advantage their meaningful, principled, and purposeful interactions.

“Much as scientists faced with unexpected patterns of data are propelled to think harder, run further experiments, or change their methods of inquiry, untutored preverbal minds are sensitive to conflict between the predicted and the observed, and use conflict [and constraints] as a scaffold for new learning” (Vygotsky (1986)). It is thus imperative to frame problem-solving as one constraint-satisfaction problem for the purpose of decision-making. Curiosity and creativity, intertwined by nature and necessity, are essential to dispose of misinformation and advance progress. All together, this provides a new line of inquiry on how causality grows on the self using scaffolding and social intercourse (Vygotsky (1986)), a line of attack [sic] worth pursuing on both fake news and immunology, the subjects discussed in the next two sections. Architecture, design, and the computing metaphors (such as DKA and PCAL) embrace the erection and scaffolding of the immunity enterprise. DKA holds sway on Data and information to create Knowledge and metaknowledge conducive to how to Act. PCAL feeds on data using Perception to Control and Adapt and to reminisce on both using Learning. Herd immunity becomes whole using the community that surrounds the protection and security agency and its diverse make-up where communication and sharing are common to all. Both defense and offense engage hot spots, spoofing, and adaptive target defenses using edits on demand, on one side, and imitation using authority and tradition, on the other side. Modification and triangulation underlie meta-reasoning in engaging sensitivity analysis to create contradictions and vet constraints to best challenge and reconfigure the current state (“model”) of immunity so adversity is met and apparent harm is diminished.

One can beef up on adaptation and herd immunity using either the *Swiss Cheese* or the *Repetitive Member Factor* to expand on bare and raw boosting. An assembly in both cases, using repetitive but varying components and units, shows an increase in reliability, robustness, and stability to address among other lack of inductive bias and under specification (D’Amour et al. (2020)) where “A machine learning pipeline is underspecified when it can return many predictors

with equivalently strong held-out performance in the training domain. Predictors returned by [such] underspecified pipelines are often treated as equivalent based on their training domain performance, but [are] shown to behave very differently in deployment domains. This ambiguity can lead to instability and poor model behavior in practice, and is a distinct failure mode from previously identified issues arising from structural mismatch between training and deployment domains.” Such under specification need to be met using varying stress tests that can adapt to pathogen, its domain of interest, and past practices if known. Inductive conformal prediction can serve as instructor and objective evaluator. Cross-immunity, herd immunity, and under specification are tied together and to advantage in advancing reliability and robustness.

The *Swiss Cheese* assembly builds a protective shield that becomes almost impermeable to pathogens as each layer or plank covers now for holes and openings found elsewhere. The defects and faults, spread randomly within the same organism or between them, lower the infection or transmission rate and make the pandemics exhaust faster and sooner. More substance to the same argument comes from the practice of annual vaccination and the realization that the gut is where bacteria and the immune system meet each other. Playing together in dirt does further strengthen the immune system of children. Overuse of antibiotics and strict hygiene preempts exposure to pathogen diversity and appears to lessen the emergence of natural immunity in children. We are shaped by surroundings and events so “the states of health or disease are the expressions of the success or failure experienced by the organism in its efforts to respond adaptively to environmental changes” (Dubos (1965)).

11 Fake News

Given all we know by now what does it take to make the abstract (see Fig. 1 and 2) on fake news become concrete? What does “fake” mean? Something (here only text but there is also multi-media to contend with) can spread in social media (see bots, echo chambers, followers, trolls, and trends that go viral). What lacks corroboration and can be easily challenged and disproved counts as fake. As reality and truth are not the same (see Sect. 4) it follows that distortion and fake are at times imponderable to decide upon. Bait, propaganda, and sentiment are such examples. What permeates throughout the search for fake, however, is the opportunity for falsifiability. Such opportunities, context driven and framed, are created by the human agency that controls immunity using active learning and sensitivity analysis. (Breaking) news, short lived and recent, are brief in contents. Reports do not count for news but their summary

distillation does. Similar comments are in order for bullshit news discussed earlier.

The pyramid that holism spans includes conceptual layers of increasing complexity and contents that are timed and timely to approximate on (a) carving and granularity on parsing and representing events (including headers and captions with some of them misleading and not matching their contents and context) and material distribution, if any, as they occur, (b) reputation of author and source, impact and intent, including conspiracy, gain (hurt reputation and monetization), post-truths, sarcasm and satire, (c) relevance using familiarity and strangeness, curiosity, emotion and sentiment (see trolls), and surprise, and (d) putative but distributed subject and identity assignments. Triangulation, incremental in nature and seeking for that fixed point where consensus and coherence meet, is built around open set transduction, TCMR, boosting and transduction, and ICP. Not only the source of but also the target for the fake news is important as their interplay mediates between holism and triangulation. Editing services (and platforms) make it both easy to spread fake news. Bait and motivation (e.g., public opinion manipulation) fuel how fast and far the fake news can spread, to what extent they supersede true news, and how entrenched they become to be dislodged?

Holism and triangulation interface to create **HATS** immunity that absorbs and learns how to avoid harm using background and experience on generic adversity and particular threats. HATS can exchange experience and insights with other individual agencies that share similar challenges on how to avoid fake news and build herd immunity. Multi-task and transfer learning and transposition can advance such efforts using stratification among other. Falsifiability searches for contradiction and Trojan horses to fight fabrication and speculation. This is generic but becomes concrete for each domain on its own terms. There is, however, the possibility that correlation holds sway between varying domains (and even cognitive layers), e.g., politics and science or elections and health care. Such cross-talk, if any, could be further discerned as causative in nature. Either way, it is up to triangulation to use any kind of cross-talk found to advantage and be aware of both unconscious and conscious biases. Immunity is challenged by wide proliferation during pandemics. As demographics, infection rate, and size matter, coupling ICP, pool testing, and tracking helps. Nothing happens in void but rather in ecosystems where misinformation and disinformation, impersonation and spoofing, and de-identification and anonymity live together to make fake news and manufactured content synonyms.

Deliberate or not and notwithstanding what is found as fake has to be revealed and upend the body of knowledge of each agency so it properly acts. The same fixed point that triangulation seeks for should also make clear the reason for the fake news as top-down causation is conducive

to filter out tracks that lead nowhere and their proliferation. Education (e.g., critical thinking and reading that some call media literacy), fines and penalties, and regulation can further help to spot and avoid fake news and their abuse of public trust. The coupling of contradiction and sensitivity analysis tops holism and triangulation and manage their intertwined logistics. The self and the crowd learn from each other and reinforce each other to reach herd immunity. Corner the fake news on the defensive side and use contradiction and truth as mental vaccination [sic] to black list and destroy the reputation of the sites and sources that fabricate news rather than report news as they break out. Evasion and pursuit or alternatively cat and mouse play each other and change roles. Triangulation can play both roles and further integrate the biometrics and forensics involved (Toor and Wechsler (2018)).

12 Herd Immunity and Vaccination for COVID-19

Similar background, frame of operation, and methods to those discussed in the preceding Sects. 8–10. Everything about infection and pandemics, in general, and COVID-19, in particular (see Roy M. Anderson et al.(2020), Mark Thompson et al.(2021), and Jeffrey V. Lazarus et al. (2021) on particulars of challenges in creating herd immunity, estimates on vaccine effectiveness, and global acceptance of COVID-19 vaccine, respectively). The challenge now is to test for and detect harmful pathogens, and fight COVID-19, if found, to avoid harm. HIPAA holds sway on privacy and regulation. The goal is to build herd immunity using vaccination. Nature and nurture cooperate to build immunity using natural genetic engineering and neural group selection. Some assembly is required (Shubin (2020)) to compose new but better artificial strains for vaccination purposes using trial and error and to have them tested for efficacy. This takes collaboration and competition using both horizontal [sic] and vertical inheritance. Inheritance of acquired traits, surprise surprise, and jumping segments between genetic strains, are new ways to express cross-over and transadaptation. Artificial (“acquired”) immunity for change can now use (“synthesize”) messenger RNA (mRNA) (to encode instructions on how to make proteins that trigger an immune response) rather than DNA (using live but weakened or inactivated pathogens) to make antibodies that bind to coronaviruses. Note that mRNA is only an intermediate step between the translation of protein encoding DNA and the production of proteins. Triangulation is aware of and engages the novel mRNA metaphor for vaccination. The same metaphor helps overall security as well in fighting against and training on adaptive and persistent threats.

Triangulation can also engage and test for assistance using therapeutic means such as statins, remdesvir, ACE inhibitors (as the virus employs its spike protein to attach to ACE-2 receptors and pry its way inside the cell), hydroxychloroquine, and vitamin D that have recently shown some promise in treating patients afflicted with COVID-19. Even an innate-immunity vaccine can be of help to boost the first line of defense and so to build multiple moats of defense. Interferon and the Sabin Oral Polio Vaccine or OPV have also been proposed as ways and means to stimulate innate emergency immune response to COVID-19 and to make herd immunity fences wider in reach and scope. This is in tune with autonomic computing and stratification. It helps with preliminary filtering and testing using open set transduction and sensitivity analysis on particular antigens, cohorts, and demographics. The COVID-19 pathogen attacks on multiple fronts. It engages the host cell to replicate itself, and have the cell destroyed at times. Harm varies but can become widely spread. Triangulation needs to survey the holistic pyramid for an added morbidity layer that contributes to harm. Old age, diabetes, ethnicity and gender, chronic disease, and overall hygiene, state of health, and work habits. Morbidity varies and as so do adversity effects, symptoms, and how the infection can spread. Such informative layers are added to augment the reach of what holism does and need to span in order to keep pace with a virus that so far has “outsmarted” science (Hotz and Khan (2020)).

Open set recognition (e.g., TCM-R) provides a suitable framework to emulate the immunity paradigm. Demarcate and detect even adversarial (“zero-day”) attacks that have never been seen before (e.g., the non-self) from the current self (e.g., the manifold of normal patterns of behavior and expression). Antibodies to remedy harm and infection are continuously created when their extant arsenal is not on par to fight the pathogens deployed by the intruder. Antibodies are evaluated for both affinity and avidity in matching antigens (non-self) using clonal (“negative”) selection on say “network” access and activity patterns conducive to purge any deleterious impact on antibodies. Affinity and avidity describe the binding energy between an antibody and an antigen. Affinity stands for the binding energy between one paratope and one epitope, while avidity stands for the combined strength of all binding sites on a single antibody molecule. The paratope and epitope stand for the binding regions of an antibody and antigen, respectively. Avidity becomes of interest when some antibodies are multivalent and can bind to multiple agents. Affinity and avidity are tied together to support attribute selection and ranking in a fashion similar to how cohorts engage open set transduction for recognition purposes. Such interplay facilitates clonal selection including positive selection when new and advantageous genetic variants sweep a population. Combined vaccines to fight both COVID-19 and flu are now contemplated.

Mutual information underlies how open set transduction estimates and creates filters and wrappers to render patterns and so to recognize or reject them. Adversarial learning using the random Hough transform (RHT) is boosting immunity as it edits the antibodies that have been “spoofed” by pathogens using impersonation during negative clonal selection. A good intrusion detector should have a high non-self affinity and low self-avidity. Additional functions of interest include apoptosis (e.g., programmed cells death) to discard some tentative antibodies from further consideration and the provision of danger SOS signals that indicate damage during positive selection. Too much of immunity, however, can still be challenging. This comes when inflammation and overreaction occur to create a cytokine storm that can be fatal. Negative selection and recognition take place using open set transduction using re-identification to seek among others for similar antigens that can be traced to the same source of attack. The need for re-identification further comes from the fact that the multitude of antigens shares common characteristics and can be traced to some original but common source(s). The longest common sequence (LCS), one indicator and source, is found using dynamic programming (DP) and/or RANSAC (e.g., RHT). Positive selection helps in facing adversarial attacks as they anticipate weak points in defense that are susceptible to be overwhelmed by adaptive and persistent threats (ATP) and the attacks that ensue. What about if and when the viruses further develop and mutate something that belongs to the cat and mouse game of evasion and pursuit?

13 Case Studies and Discussion

We discuss here a number of case studies to illustrate the novel methodology advanced in this paper on combatting both fake news and deep fakes, on one side, and following the best practices on mitigating COVID-19, on the other side. The case studies follow on the scientific tradition of thought or Gedanken experiments³ where principled hypotheses are laid out for the purpose of thinking through their consequences, in general, and advantages, in particular. This comes due to the fact that relevant (big) data is proprietary in nature whereby public information to reckon with is readily available. Before we undertake our case studies it is important to spring forth the framework that embraces our discussion. The framework used accounts for mass production of information, disinformation and all, and it can be traced to Edward Bernays.⁴ The frame is that of (mass) propaganda⁵

³ https://en.wikipedia.org/wiki/Thought_experiment.

⁴ https://en.wikipedia.org/wiki/Edward_Bernays.

⁵ [https://en.wikipedia.org/wiki/Propaganda_\(book\)](https://en.wikipedia.org/wiki/Propaganda_(book)).

and has anticipated current media and its use of social networks. As one would expect the methods used to face adversity engage adversarial learning that permeates the scaffold erected using holism and triangulation.

13.1 Disinformation and Fake News

The underlying theme here is how to face confabulation (fabricated, misinterpreted, or distorted information) and deception that among other engage suppression of open discussion and diversity of opinion in order to amplify instead fake news using both short sloganeering and story-telling that uses to advantage novel but powerful text generating tools such as GPT-3 where the good and the bad are entangled (Strickland (2021)). The good side creates characters such as customer service representatives and video game characters while the bad side can generate at times offensive language including confabulation, deliberate or not. Power comes from brute force but mindless training using statistical correlation that lacks any understanding. One way to face such adversity is to first use crowd sourcing of web postings on the same subject that are weighted by reputation and source, on one side, and adversarial learning (see Sect. 9) where text is first briefly edited and redacted and then aggregated to seek consensus and discern truth, if any. Suppression of news deemed to be faked ones can become on itself core to additional fake news and influence user behaviour on a bevy of activities including health and voting practice (see for the latter Epstein (2015)). What are fake news is a problem on its own that involves the ambience of echo chamber (iteration and recursion) adversarial learning and seasoned acumen about source and their intent and reputation.

13.2 Art and Deep Fakes

Yet another source of disinformation and much fraud (easy to commit but hard to identify) is found both in deep fakes (see Farid (2016)) and in art, the latter both traditional and digital. Examples abound but for brevity we consider some well known cases. Highlights of fraud in traditional art are many but some stand out. The Last Vermeer [sic]⁶ (2019 film directed by Dan Friedkin based on Jonathan Lopez 2008 book *The Man Who Made Vermeers*) recounts the story of the painting's discovery and exposure as a fake that earlier during WWII swindled (positive [sic] valence here) millions of dollars from the Nazis by selling them forgeries of Johannes Vermeer. The success of such grand scale forgery has been attributed to reputation and similitude, on one side, and subliminal credibility that was created by the enormous price charged. Again simple but adversarial viewing (see

above) and analysis would have found significant discord to the style espoused by Vermeer and also discrepancies in composition. More recently such analysis has been undertaken using fractal analysis on the drip (splashing liquid household paint) paintings "attributed" to Jackson Pollock only to found them as forgeries⁷ and make Pollock perhaps the most-forged postwar artist. Worth to note that the high prices involved in both cases gave an aura of authenticity to forgeries. Monetary reward is thus a warning that needs to be heeded and usually is. There is monetary reward in both Fake News and Deep Fakes if only one were to follow the money trail. We note the recent use of non-fungible token (NFT) or digital certificates using digital ledgers that engage to advantage block chains. They mark digital art work as unique digital items that are not interchangeable (see the Bepple NFT that has become the most expensive ever sold art work at an auction held by Christie after fetching over \$ 60 millions⁸). The use of NFT like tokens illustrates how source and reputation can be validated to earn trust and become tokens of interest to both holism and triangulation can meet each other.

13.3 COVID-19

Some case studies about herd immunity and vaccine acceptance and effectiveness have been referred to earlier (see Sect. 12). They are all challenging on themselves as they contribute to the way progress is made to combat the COVID-19 pandemic. Efficacy and duration of protection bear on how immunization using mass vaccination becomes the norm that could become publicly accepted. They are, however, unknown at this time and only preliminary and at times anecdotal evidence some using antibodies concentration ("titres") is currently available. One way to surpass the limited temporality of evidence is to entertain the incremental coupling of anticipation and adversarial learning on what can be expected, on one side, and how the time series that become available can be interpreted and reinterpreted to find out how methods on imputation and curation using mass vaccinations compare against each other. Eliza Strickland and Glenn Zorpette (2020) have recently and convincingly argued that foresight that draws to advantage on informed communities and tech such as fast and accurate testing and digital contact tracking have been the winning combination to contain, lessen, and hopefully bring to an end the current pandemic. Foresight and anticipation are intertwined and are the mark of mental acumen and acuity that are timely

⁶ https://en.wikipedia.org/wiki/The_Last_Vermeer

⁷ <https://news.artnet.com/market/richard-polsky-broadens-authentication-services-to-include-jackson-pollock-1441975>

⁸ <https://www.cnn.com/2021/03/11/most-expensive-nft-ever-sold-auctions-for-over-60-million.html>

deployed, on one side, and grounded and situated, on the other side.

The history itself of how vaccines are created and produced can be instructive on its own (see Allysia Finley interviewing Alex Gorsky, the CEO of Johnson and Johnson, on the vaccine revolution (weakened or inactivated viruses, vector vaccines using the likes of genetic engineering, and most recently mRNA to teach our cells how to make the proteins that trigger an immune response).⁹ It's all about priming the immune system to manufacture the doppelgangers that "trigger an immune reaction, marshaling anti-bodies and white blood cells. The body recognizes the virus and begins producing antibodies alongside B-cell ("sentinels") and T-cell ("back-up using kind of photographic memory to stick around longer") response" (see Sect. 8). The immune system, layered in nature, is well aligned to how holism and triangulation (see Sect. 3) are responsive in discerning infection (see Sect. 7) and providing protection. Overall and in summary Think Globally but Act Locally is the lesson that should be kept in mind and followed if and when needed.

14 Conclusions

This paper advances a novel HATS methodology to mediate reality and truth on herd immunity using Holism, Ambient Intelligence, Triangulation, and Stigmergy. Ambient Intelligence and Stigmergy mediate Meta-Reasoning using the interplay between Sensitivity Analysis and Transduction. As everything is fluid and change is constant it helps to recondition reality (e.g., modification) and to gate and reconfigure the coupling of form, function, method, organization and structure. Some edits, adaptive, situated, and at times spontaneous in nature, expand on the concept of moving target defense to introduce horizontal and vertical causality using inheritance (see Holism) and repurpose that supersede on mere correlation using causality. Open set transduction is core to the whole enterprise. Nothing less than life-long learning that mediates calibration and validation using conformal prediction and cross-talk is needed. HATS builds on the familiar past but keeping eyes wide open to the future and what it holds sway on. As such it reconditions and reconstructs the past to make sense of the present and anticipate the future. The potential of immunity goes beyond bare fake news and COVID-19. It can address fraud and hate discourse using de-identification and re-identification and meter the extent to which manufactured content would radicalize the audience and outwit scrutiny using sentiment analysis.

⁹ <https://www.wsj.com/articles/capitalism-is-what-will-defeat-covid-11616192690>

The multi-media is the next frontier where HATS can be launched to engage visual query answering (Toor et al. (2019a) and Toor et al. (2019b)). This is where physical contents and text are embedded to come together and where action and events ("verb") have been found to take precedence over object ("noun") using relevance and reputation. Another coming challenge for HATS is to distribute and share constraint-satisfaction problem-solving and decision-making capabilities using the interplay between edge, fog, and cloud computing. Efficiency but not at the expense of efficacy. As time begets events and space, trajectories that the news travel on are worth to investigate if not more so than the news themselves. As news are rarely unique events but rather are assembled and composed on demand, natural genetic engineering, in general, and CRISPR-Cas9, in particular, can and should join the arsenal of HATS to focus on mutations that evade pursuit and annihilation. Another related question is to find out if the fake news are human or bot made and similar in reach and scope to inquire the extent to which pandemics are natural in origin or man-made.

An additional subject of interest is related to universal roots and herd immunity. Universal roots refer to what stays invariant and can always be found notwithstanding evasion. Pathogens do mutate but there is some core there that stays the same. Herd immunity has to do with stigmergy. Collective behavior expands beyond introspection to cover how swarm particles share and reinforce each other to diminish the overall infection rate and become immune sooner rather than later. Yet another topic worth further investigation concerns cross-immunity where "[It was] now proven that, in some people, pre-existing T cell memory against common cold coronaviruses can cross-recognize SARS-CoV-2, down to the exact molecular structures," and according to Dr. Daniela Weiskopf, one of the study's authors, "This could help explain why some people show milder symptoms of disease while others get severely sick" (Lee (2020)). Combined vaccination is thus not far in the offing.

Declarations

Conflict of interest "The authors declare no conflict of interest. The funding agency had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results".

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