Semantic Patterns of Prohibited AI Systems in the EU AI Act

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Abstract

The EU AI Act is a landmark piece of legislation that governs deployment and use of AI systems. Within its risk-based regime of regulation, prohibited AI practices face the strictest requirements, being entirely banned to be deployed or used within the Union. The provisions for prohibited systems have been applied since 2 February 2025. While authoritative guidelines have been published for prohibited systems, there is still no systematic approach that facilitates determination of such systems in a simplified and automated manner. To fill this gap, we specify the prohibited AI conditions, articulated in Art. 5, using combination of a minimal set of semantic concepts. We further show how these conditions can be described in a machine-readable format using semantic constraint and rule languages, such as SHACL and N3. This approach to representing prohibited rules facilitates open, interoperable, auditable, and automated implementation and enforcement of the AI Act.

Keywords

EU AI Act, prohibited AI, semantic rules, SHACL, N3

1. Introduction

The EU AI Act [1] is the first in the world AI regulation that entered into force on 1 August 2024. Adopting a risk-based approach, the AI Act regulates AI systems according to their potential risks to health, safety, and fundamental rights. Within this risk-based classification, the Act explicitly identifies two categories of AI systems: (1) *prohibited AI practices*, defined in Art. 5, and (2) *high-risk AI system*, specified in Art. 6. In addition, the Act implies another class of AI systems that impose *transparency* risks in Art. 50 . Finally, it refers to *"AI systems other than high-risk"* (Art. 95), which are subject to voluntary compliance with the legal obligations, this category is interpreted as " minimal risk AI systems". Within this categorisation, prohibited AI practices face the draconian measure of being entirely banned to be deployed or used within the Union. In case of non-compliance, providers and deployers of such systems face fines up to EUR 35 million or 7 percent of the offender's total worldwide annual turnover, whichever is higher (Art. 99(3)).

The AI Act outlines eight main categories of prohibited practices in Art. 5. Four of these categories are banned unconditionally, while the remaining four are subject to exceptions. Although the number of conditions is limited, the legal language used to describe them is vague and open to interpretation (see the discussions in [2, 3, 4]). To assist with implementation of the Act and as per Art. 96(1b), the Commission published a guideline on prohibited AI practices [5] in February 2025. While this guideline is a helpful resource to resolve ambiguities, it does not necessarily simplify the critical decision of whether an AI system is prohibited or not.

Unlike the power of adopting delegated acts for updating Annex III high-risk AI systems (Art. 7), there is no agile mechanisms to amend the list of prohibited AI systems as the AI technology as well as social preferences change. Therefore, any changes to the prohibited conditions requires following the ordinary legislative procedure, which can take several years [6]. Although the frequent changes to prohibited systems might be unlikely, the rapid pace of changes in AI systems requires adaptable

NXDG 2025, NeXt-generation Data Governance workshop 2025
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approaches that enable ongoing assessment the system's risk level to avoid any non-compliance. In this paper, we aim to facilitate identification prohibited AI systems by determining the *minimal* set of concepts that enable specifying prohibited AI systems in a way that they can be sufficiently distinguished. After conceptualisation of prohibited conditions, we demonstrate how these can be translated into codified machine-readable rules using Semantic Web technologies, particularly the Shapes Constraint Language (SHACL) [7] and Notation 3 (N3) [8]. By leveraging Semantic Web technologies, we develop a standards-based, transparent, interoperable framework for determining prohibited AI conditions, and thereby supporting automation of compliance-related tasks. As will be discussed later, this work is build on top on our previous work for determining high-risk AI systems [9], which has received a great traction from the community.

2. Related Work

Existing studies on the AI Act's prohibited AI practices (Art. 5) are primarily focused on interpreting the prohibited conditions. Some notable analysis have been published before the publication of the AI Act in official journal of the EU, including Neuwirth's analysis of prohibited categories stated in the commission's proposal [10], Bermúdez et al.'s effort to provide a definition for subliminal techniques [2], Franklin et al.'s proposed definitions for subliminal, purposefully manipulative and deceptive techniques [3], Bulgakova's analysis of the prohibition on the use of subliminal techniques [4], and Leiser's comparative analysis of prohibited uses that deploy manipulative techniques in different mandates of the Act [11]. However, the recent publication of the Commission's guidelines on prohibited AI systems [5] has addressed several issues previously highlighted in these studies. Since the publication of the Act and the Commission guidelines on prohibited AI, there are few studies, including Barkane and Buka's critical analysis of the prohibitions of surveillance and predictive policing [12], have been published. In general, the body of work on the criteria for prohibited systems is mainly focused on clarification of the wording of the Act's text and none of the aforementioned studies, in addition to the Commission's guidelines, establish a *holistic view* of the prohibited categories, nor do they identify the set of concepts of AI use cases that make them prohibited.

In regard to the **codification** of rules for AI Act's risk categorisation, the D*ecision-Tree-based framework* [13] is a static framework that aims to assist in classification of AI systems based on the AI Act. The framework is based on a decision tree comprising 20 questions for determining the risk category associated with an AI system. To assist with determining high-risk AI systems as per Annex III, in our pervious work [9], we identified 5 concepts: domain, purpose, AI capability, deployer, AI subject. We further codified the rules using SHACL to assist with determination of such systems. Given the traction our work on high-risk AI has received from the community, in this paper we follow the same approach for prohibited practices.

3. Methodology

Identification of classification rules for the AI Act's prohibited AI practices is guided by our contributions in [9]. As pointed out earlier, thorough annotation of Annex III of the AI Act, we identified the minimum set of information elements (the 5 aforementioned concepts) required to determine high-risk applications of AI. Building on top of these identified information elements, we take the following steps to create a framework for determining prohibited AI practices (see section 4):

1. Identify the 5 concepts from each prohibited condition described in Article 5(1),
2. Determine whether the 5 concepts are sufficient to describe prohibited AI practices in a unique way that sufficiently distinguish them from each other,
3. Where the 5 concepts are not sufficient, identify the minimal set of additional concepts needed for describing the prohibited AI condition.

To be able to provide open data specifications for prohibited systems, we add the identified additional concepts (step 3) to the AI Risk Ontology (AIRO) [14][1] and further populate the Vocabulary of AI Risks (VAIR)[2] with the instances identified from the annotation process.

Demonstrating how the prohibited AI rule-checking can be automated for supporting compliance tasks, we utilise existing Semantic Web languages and standards with rule-checking capabilities. While there are multiple languages and standards offering such capabilities, including the Shapes Constraint Language (SHACL) [7], the Semantic Web Rule Language (SWRL) [15], N3 (Notation3) rules [8], and the Shape Expressions (ShEx) language [16], we use SHACL in this work as it is a W3C recommended language. We also use N3 to express rules in a simplified if-then style manner to address the complexity of expressing the rules using SHACL (see section 5).

4. Patterns of Prohibited AI Practices under the AI Act

The analysis Art. 5(1) aims to identify the minimum set of concepts that are adequate to uniquely describe prohibited AI practices. Following the steps outlined above, Art. 5(1) clauses that were annotated to identify the 5 following concepts: domain, purpose, AI capability, deployer, AI subject. Then, additional concepts were identified in each clause. An example of annotating Article 5(1a) is shown in Figure 1.

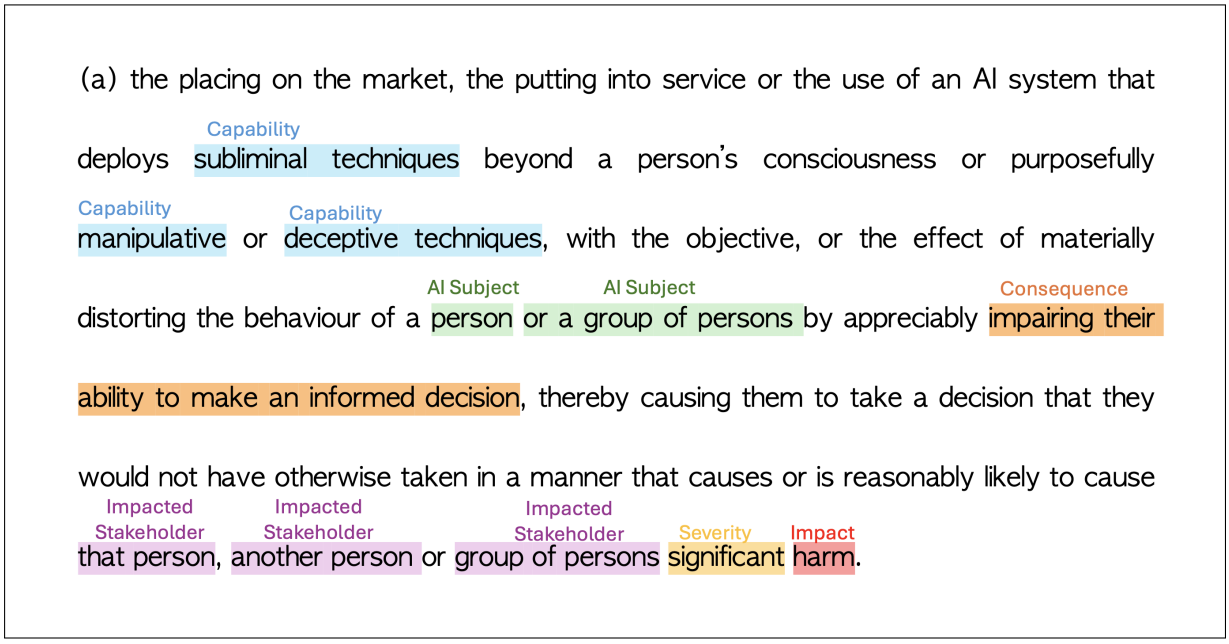

Figure 1: Annotation of prohibited AI practice described in Article 5(1a)

The annotation exercise revealed that among the 5 previously identified concepts, AI deployer is not a decisive factor in determining prohibited AI systems. Additionally, we identified the following additional concepts: ***data processed by the system***, ***locality of use***, ***consequence***, ***impact and its severity***, and ***impacted stakeholder(s)***. ***Locality of use*** defines to the environment in which the system is used, e.g. work place. ***Consequence*** refers to the direct immediate effect of using an AI system, whether it leads to harms to individual, groups, and society or not. ***Impact*** refers to the overall ultimate effect of an AI system on ***impacted stakeholders***, such as individual, groups, and society. We treat the combination of consequence, impact, and its severity, and impacted stakeholder as ***(harmful) risk requirement*** on the basis that these concepts can only be determined through risk assessment.

[1]https://w3id.org/airo
[2]https://w3id.org/vair

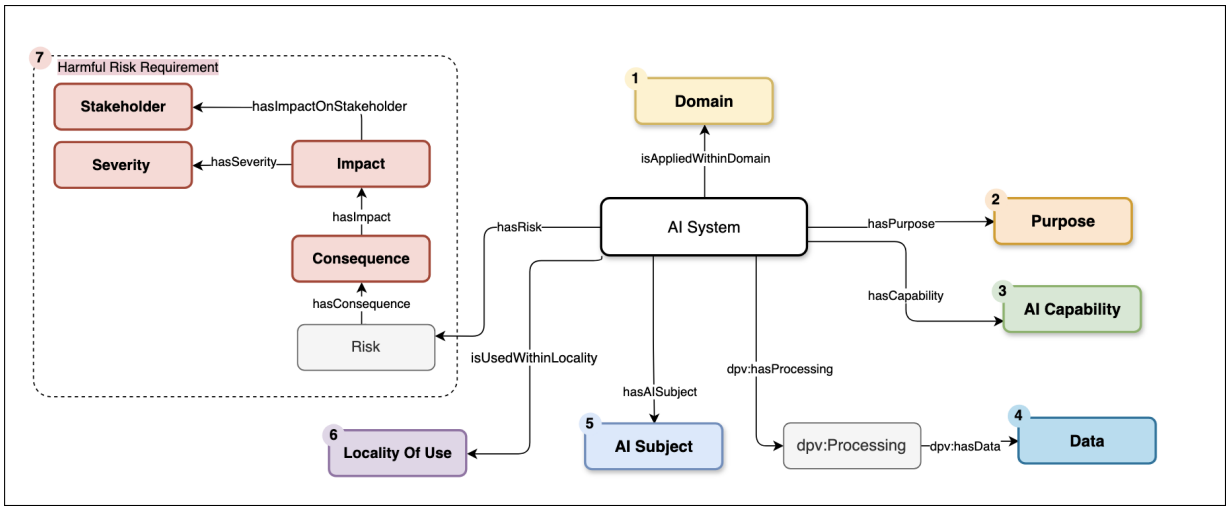

Figure 2: Semantic model of concepts (from AIRO) required for determining prohibited AI systems as per Art. 5(1)

Our analysis shows that among the prohibited conditions in Art. 5(1), points (a), (b), and (c) depend on the results of the risk assessment process to identify the consequence, impact, severity of impact, and the impacted stakeholder.

The minimal set concepts for determining prohibited AI systems are expressed in a form of questions in the following:

1. In which ***domain*** is the AI system used?
2. What is the ***purpose*** of using the AI system?
3. What is the ***capability*** of the AI system?
4. What ***data*** is processed by the AI system?
5. Who is the ***AI subject***?
6. What is the ***locality of use***?
7. what is the ***harmful risk*** caused by the AI system?
   a) What is the ***consequence*** of using the system?
   b) What is the ***impact*** of using the AI system?
   c) What is the ***severity* of the impact**?
   d) Who is the ***impact stakeholder***?

These concepts and their relations are modelled in our previously developed ontology for AI risks, AIRO, are illustrated in Figure 2. As shown in the figure, concepts from the Data Privacy Vocabulary (DPV) [17] are reused for expressing the data processed by the system.

The detailed analysis of the prohibited conditions is presented in Appendix A and a summary of the conditions is illustrated in Figure 3. It should be noted that in our analysis of Article 5(1) points (a) and (b), we consider *materially distorting behaviour* as a consequence rather that purpose of the system, even though the wording of the AI Act suggests that it can be either an *objective* or an *effect* of employing the AI system. This interpretation is based on the reality that AI providers rarely, if ever, explicitly state that their system's purpose is "behaviour distortion" or "impairing decision making". Further, in development of emerging technologies such effects of AI are often identified after deployment as (unintended) consequences.

5. Codified Rules for Determining Prohibited AI Practices

In our framework, prior to rule-checking, an RDF-based specification of an AI systems should be created to enable determination of its risk category. In Listing 1, machine-readable specification of an AI chatbot

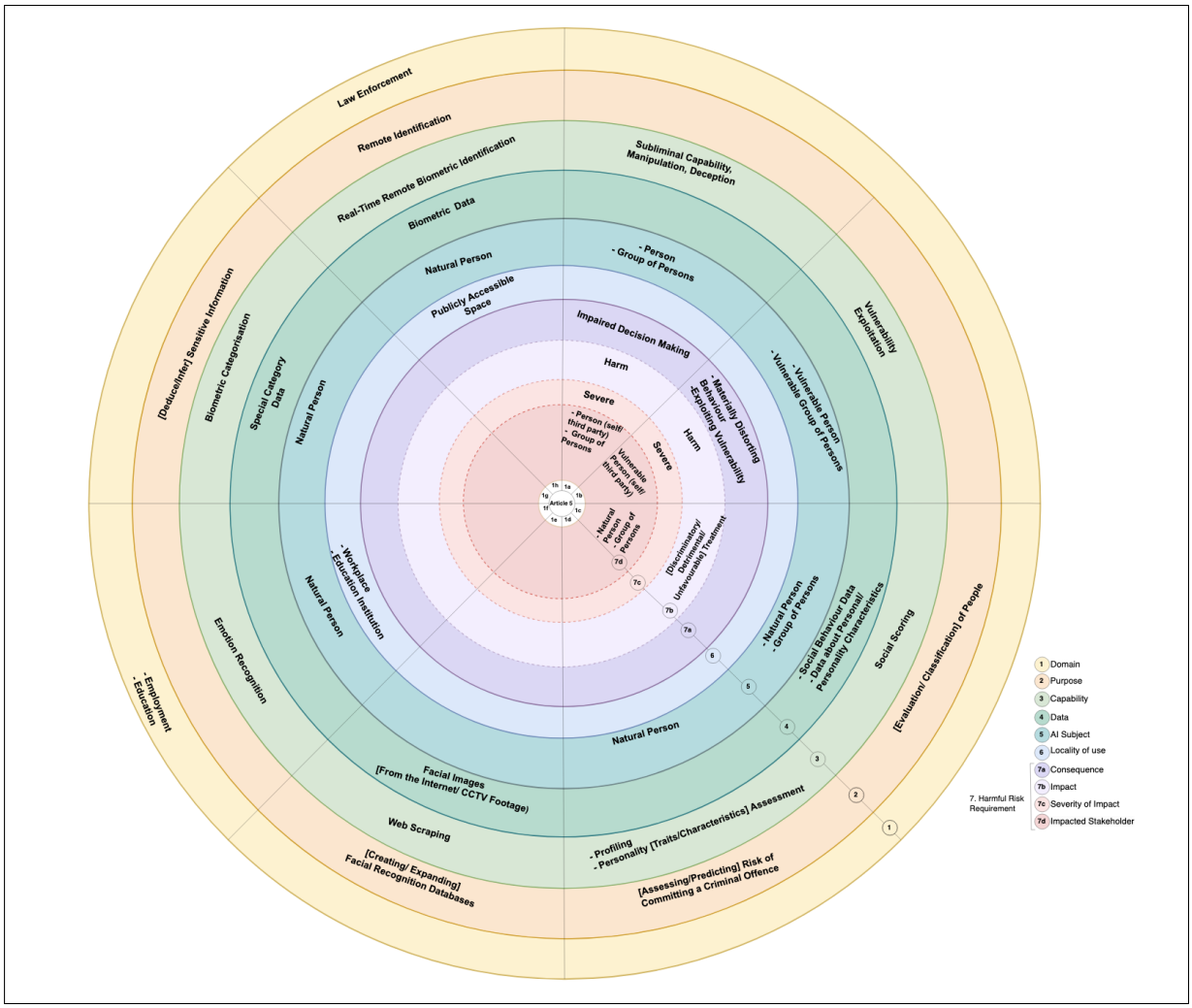

Figure 3: Patterns of prohibited AI practices

that impersonates a friend of a person for scamming, described in the Commission's guideline [5], is shown. This specification serves as a *data graph* that can be validated against the *shape graphs*, which describe the rules for prohibited AI systems.

An example of a shape graph specifying Art. 5(1a) condition is shown in Listing 2. As it is clear in the listing, the shape graph is expressed as negation of the condition using `sh:not`. This is due to the fact that SHACL's validation report (`sh:ValidationResult`) is only generated in case of non-conformance. We used the validation report to enhance transparency by providing guiding information about the clause based on the which the system is determined to be prohibited.

As shown in the listing expressing the the harm requirement within a SHACL shape graph requires nested `NodeShapes` which adds to complexity of the shape and further effects its readability and performance. To address this, in Listing 3, we show how N3 can be used to provide a simplified representation of the rule for Art. 5(1a).

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix airo: <https://w3id.org/airo#> .
@prefix vair: <https://w3id.org/vair#> .
@prefix dpv: <https://w3id.org/dpv#> .
@prefix ex: <https://example.com/> .

ex:ai_chatbot a airo:AISystem ;
    airo:hasPurpose ex:engage_in_human_like_conversation ;
    airo:hasCapability ex:impersonation ;
    airo:hasAISubject ex:chatbot_user ;
    airo:hasRisk ex:risk_of_fraud;
    dpv:hasProcessing ex:processing_conversation .

ex:engage_human_like_conversation a airo:Purpose .

ex:impersonation a airo:Capability , vair:DeceptiveTechnique .

ex:chatbot_user a airo:AISubject, dpv:DataSubject .

ex:processing_conversation a dpv:Processing ;
    dpv:hasData ex:voice .

ex:voice a dpv:PersonalData .

ex:risk_of_fraud a airo:Risk ;
    airo:hasConsequence ex:victim_tricked_into_transfering_money .

ex:victim_tricks_into_transfering_money  a airo:Consequence, vair:ImpairedDecisionMaking ;
    airo:hasImpact ex:financial_loss .

ex:financial_loss a airo:Impact ;
    airo:hasSeverity vair:Severe ;
    airo:hasImpactedStakeholder ex:chatbot_user .

ex:impersonation a vair:Deception .
```

Listing 1: RDF-based specification of the AI chatbot example

6. Conclusion and Future Work

In this paper, we presented a codified framework to assist with determining prohibited AI systems according to the AI Act. This paper followed the approach we took in our previous work for determining high-risk applications [9] in terms of both conceptualisation and codification. Although these two work are aligned and complementary, they have not yet integrated to capture the interplay between the two categories. Thus, in our future work, we aim to address this gap by incorporating the exceptions to prohibited systems, given that these exceptions are mostly result in the system being classified as high-risk [5]. For those AI systems listed in Annex III (high-risk AI systems) but may also meet the prohibited conditions, and therefore be classified as prohibited, we propose a sequential classification wherein determining prohibited AI supersedes high-risk AI. In our future work, we also aim to include the specificities from the Commission's guidelines on prohibited systems [5] and further populate VAIR, for example with instances of subliminal techniques, including visual subliminal messages, subvisual and subaudible cueing, and misdirections. We also plan to propose these concepts for inclusion within DPV.

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix airo: <https://w3id.org/airo#> .
@prefix vair: <https://w3id.org/vair#> .
@prefix ex: <https://example.com/ns#> .

ex:Art5-1a
    a sh:NodeShape ;
    sh:targetClass airo:AISystem ;
    sh:message "Prohibited as per AI Act, Art. 5(1a): AI system that deploys subliminal techniques
    ↪ beyond a person's consciousness or purposefully manipulative or deceptive techniques, with
    ↪ the objective, or the effect of materially distorting the behaviour of a person or a group
    ↪ of persons by appreciably impairing their ability to make an informed decision, thereby
    ↪ causing them to take a decision that they would not have otherwise taken in a manner that
    ↪ causes or is reasonably likely to cause that person, another person or group of persons
    ↪ significant harm"@en ;
    sh:description "AI systems that AI system that deploys subliminal techniques beyond a person's
    ↪ consciousness or purposefully manipulative or deceptive techniques"@en ;
    sh:not [sh:and (
                sh:property [
                    a sh:PropertyShape ;
                    sh:path airo:hasCapability ;
                    sh:class vair:Deception ; ]

                sh:property [
                    a sh:PropertyShape ;
                    sh:path airo:hasAISubject ;
                    sh:or (
                        [ sh:class vair:NaturalPerson ; ]
                        [ sh:class vair:Group; ] )
                    ]
                #harmful risk requirement
                sh:property [
                    a sh:PropertyShape ;
                    sh:path airo:hasRisk ;
                    sh:node [
                        sh:property [
                            sh:path airo:hasConsequence ;
                            sh:node [
                                sh:class vair:ImpairedDecisionMaking ;
                                sh:property [
                                    sh:path airo:hasImpact ;
                                    sh:node [
                                        sh:class vair:Harm ;
                                        sh:property [
                                            sh:path airo:hasSeverity ;
                                            sh:class vair:Severe ; ];
                                        sh:property [
                                            sh:path airo:hasImpactOnStakeholder ;
                                            sh:class vair:NaturalPerson ; ] ] ] ] ] ) ] .
```

Listing 2: SHACL shape for identifying prohibited AI systems from Art. 5(1a)

Acknowledgments

This work has received funding from the European Commission's Horizon Europe Research and Innovation Programme under grant agreement No. 101177579 (FORSEE), the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No.

```
@prefix airo: <https://w3id.org/airo#> .
@prefix vair: <https://w3id.org/vair#> .
@prefix ex: <https://example.com/ns#> .
@prefix list: <http://www.w3.org/2000/10/swap/list#> .

{
   ex:my_system airo:hasCapability ?capability .
   ?capability a vair:Deception .
   ex:my_system airo:hasAISubject ?subject .
   ?subject list:in (
        vair:NaturalPerson
        vair:Group ) .
   ex:my_system airo:hasRisk ?risk .
   ?risk airo:hasConsequence ?consequence .
   ?consequence a vair:ImpairedDecisionMaking .
   ?consequence airo:hasImpact ?impact .
   ?impact a vair:Harm .
   ?impact airo:hasSeverity vair:Severe .
   ?impact airo:hasImpactOnStakeholder ?stakeholder .
   ?stakeholder list:in (
        vair:NaturalPerson
        vair:Group ) .
} => { ex:my_system a ex:Prohibited-5-1a . } .

```

Listing 3: N3 rule for identifying prohibited AI systems as per Art. 5(1a)

813497 (PROTECT ITN), and from the ADAPT Centre for Digital Media Technology, which is funded by Research Ireland and is co-funded under the European Regional Development Fund (ERDF) through Grant#13/RC/2106_P2. Harshvardhan J. Pandit is a member of AI Accountability Lab, which is funded under John D. and Catherine T. MacArthur Foundation grant with project #216001 and award #19034.

Declaration on Generative AI

During the preparation of this work, the first author used OpenAI's ChatGPT and Anthropic's Claude for language refinement and Microsoft's GitHub Copilot for code debugging assistance. These tools were employed in a limited capacity and after using them the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

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A. Detailed Analysis of Prohibited AI Practices

Table 1
Analysis of prohibited AI practices listed in Article 5, Points (1a) to (1e)

Art. 5 clause	Concepts
(1a)	1. **Domain**: Any 2. **Purpose**: Any 3. **Capability**: *Subliminal Capability*, *Manipulation*, *Deception* 4. **Data processed**: Any 5. **AI subject**: *Natural Person*, *Group of Persons* 6. **Locality of use**: Any 7a. **Consequence**: *Impaired Decision Making* 7b. **Impact**: *Harm* 7c. **Severity of impact**: *Severe* 7d. **Impacted stakeholder**: *Natural Person* (self or third-party), *Group of Persons*
(1b)	1. **Domain**: Any 2. **Purpose**: Any 3. **Capability**: *Exploitation Of Vulnerability* 4. **Data processed**: Any 5. **AI subject**: *Vulnerable Person*, *Vulnerable Groups Of Persons* 6. **Locality of use**: Any 7a. **Consequence**: *Materially Distorting Behaviour*, *Exploiting Vulnerability* 7b. **Impact**: *Harm* 7c. **Severity of impact**: *Severe* 7d. **Impacted stakeholder**: *Vulnerable Person* (self or third-party)
(1c)	1. **Domain**: Any 2. **Purpose**: *Evaluation Of People*, *Classification Of People* 3. **Capability**: *Social Scoring* 4. **Data processed**: *Social Behaviour Data,Known, Inferred or Predicted Personal Characteristics*, *Known, Inferred or Predicted Personality Characteristics* 5. **AI subject**: *Natural Person*, *Group of Persons* 6. **Locality of use**: Any 7a. **Consequence**: Any 7b. **Impact**: *Discriminatory Treatment*, *Detrimental Treatment*, *Unfavourable Treatment* 7c. **Severity of impact**: Any 7d. **Impacted stakeholder**: *Natural Person*, *Group of Persons*
(1d)	1. **Domain**: Any, 2. **Purpose**: *Assessing Risk of Committing a Criminal Offence*, *Predicting Risk of Committing a Criminal Offence* 3. **Capability**: *Profiling, Personality Traits Assessment, Personality Characteristics Assessment* 4. **Data processed**: Any 5. **AI subject**: *Natural Person* 6. **Locality of use**: Any 7a. **Consequence**: Any 7b. **Impact**: Any 7c. **Severity of impact**: Any 7d. **Impacted stakeholder**: Any
(1e)	1. **Domain**: Any 2. **Purpose**: *Creating Facial Recognition Databases*, *Expanding Facial Recognition Databases* 3. **Capability**: *Web Scraping* 4. **Data processed**: *Facial Images From The Internet*, *Facial Images From CCTV Footage* 5. **AI subject**: *Natural Person* 6. **Locality of use**: Any 7a. **Consequence**: Any 7b. **Impact**: Any 7c. **Severity of impact**: Any 7d. **Impacted stakeholder**: Any

Table 2
Analysis of prohibited AI practices listed in Article 5, Points (1f) to (1h)

Art. 5 clause	Concepts
(1f)	1. **Domain**: *Employment*, *Education* 2. **Purpose**: Any 3. **Capability**: *Emotion Recognition* 4. **Data processed**: Any 5. **AI subject**: *Natural Person* 6. **Locality of use**: *Workplace*, *Education Institution* 7a. **Consequence**: Any 7b. **Impact**: Any 7c. **Severity of impact**: Any 7d. **Impacted stakeholder**: Any
(1g)	1. **Domain**: Any 2. **Purpose**: *Deduce Sensitive Information*, *Infer Sensitive Information* 3. **Capability**: *Biometric Categorisation* 4. **Data processed**: *Special Category Data* 5. **AI subject**: *Natural Person* 6. **Locality of use**: Any 7a. **Consequence**: Any 7b. **Impact**: Any 7c. **Severity of impact**: Any 7d. **Impacted stakeholder**: Any
(1h)	1. **Domain**: *Law Enforcement* 2. **Purpose**: *Remote Identification* 3. **Capability**: *Real-Time Remote Biometric Identification* 4. **Data processed**: *Biometric Data* 5. **AI subject**: *Natural Person* 6. **Locality of use**: *Publicly Accessible Space* **Consequence**: Any 7a. **Consequence**: Any 7b. **Impact**: Any 7c. **Severity of impact**: Any 7d. **Impacted stakeholder**: Any