Contents

1 Introduction

1.1 Background

1.2 Business rules

1.3 Ecological interface design

2 Protocol de recherche

2.1 Questions de recherche

Questions principales

RQ1 Comment les principes de l'Ecological Interface Design ont-ils été appliqués à la représentation visuelle de règles métiers ou de systèmes de contraintes ?

RQ2 Quelles approches conceptuelles, méthodologiques ou techniques ont été mobilisées pour rendre visibles ou compréhensibles les états d'une règle métier (valide, bloquée, inactive, en alerte, etc.) ?

RQ3 Quels modèles cognitifs, ergonomiques ou informationnels ont été mobilisés pour adapter la visualisation des règles métiers au contexte d'usage (rôle utilisateur, environnement, phase de travail, niveau d'expertise, etc.) ?

Questions secondaires

RQ4 Quels types de métaphores visuelles ou structures d'information ont été proposés pour représenter la complexité des interdépendances entre règles métiers (hiérarchie, causalité, propagation d'état) ?

RQ5 Quels domaines applicatifs ont le plus exploré ces approches (ex. : systèmes industriels, ingénierie, santé, finance, administration, etc.) et dans quelles finalités (supervision, décision, audit, apprentissage) ?

RQ6 Quelles sont les limites identifiées dans la littérature concernant l'applicabilité des principes EID à des systèmes de règles dynamiques (ex. : règles générées, apprises, modifiées en temps réel) ?

RQ7 Quels modèles d'évaluation (performance, charge cognitive, compréhension, décision) ont été employés pour mesurer l'efficacité de ces interfaces écologiques appliquées aux règles métiers ?

inline [rmq::some remq] remarque. [1]

Table 1: Methode PICOC

Element	Definition	Keywords
Population **Intervention** **Comparison** **Outcome**	Non utilisé	`ecological interface design`, `EID`

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[1] text

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Element	Definition	Keywords
Context		

2.1.1 Quality assessment criteria

Justification des choix de mots-clés.

L'identification des mots clés permet de préparer la requête des bases de données. Le processus de collecte est illustré par la figure 1.

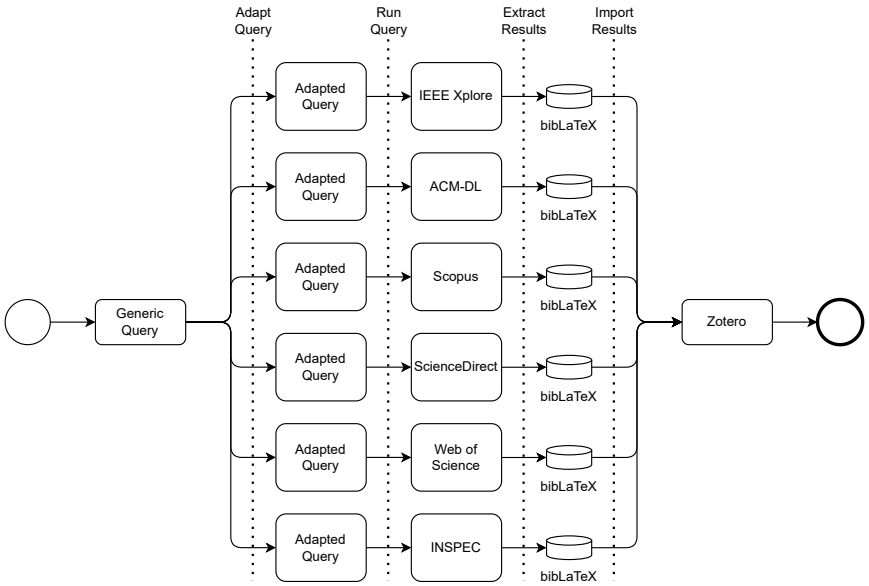

Figure 1: Processus de collecte des données

La requête booléenne générique intégrant les mots-clés issus du tableau 1 est présentée par le bloc de code 1. Sa structure suit l'ordre logique : **Population** $\wedge$ **Intervention** $\wedge$ **Outcome** $\wedge$ **Context**.

Les bases de données intérogées sont :

1. IEEE Xplore
2. ACM Digital Library : The ACM Guide to Computing Literature collection
3. Scopus
4. ScienceDirect

```
-- POPULATION: Interfaces, cognition, visualization
("human-machine interface" OR "human computer interaction" OR "human
↪  centered interaction" OR "HMI" OR "HCI")
-- INTERVENTION: Ecological Interface Design
AND ("ecological interface design" OR "EID")
-- OUTCOME: cognitive and decision-related outcomes
AND ("situational awareness" OR "context sensitivity" OR "cognitive load"
↪  OR "usability" OR "mental workload" OR "user performance" OR "task
↪  performance" OR "error reduction" OR "cognitive efficiency")
-- CONTEXT: construction and engineering disciplines
AND ("construction industry" OR "civil" OR "structural" OR "geotechnical"
↪  OR "hydraulic" OR "transport" OR "mechanical" OR "plumbing" OR
↪  "sanitary" OR "HVAC"  OR "heating" OR "ventilation" OR "air
↪  conditioning" OR "cooling" OR "climate" OR "environmental" OR
↪  "electrical" OR "power" OR "energy" OR "lighting" OR "acoustical" OR
↪  "thermal" OR "fire safety" OR "industrial" OR "maintenance" OR
↪  "construction management" OR "urban" OR "infrastructure")
```

Listing 1: Requête générique

5. Web of Science
6. INSPEC (via Engineering Village or ProQuest)

La requête générique est ainsi adaptée à chaque base de données et les variantes sont présentées par le tableau 2

Table 2: Déclinaison de la requête générique par bases de données ciblées

Base de données	Requête

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Base de données	Requête
IEEE Xplore	"All Metadata":(("human-machine interface" OR "human computer interaction" OR "HMI" OR "HCI") AND ("ecological interface design" OR "EID" OR "ecological design") AND ("situational awareness" OR "context sensitivity" OR "cognitive load" OR "usability" OR "mental workload" OR "user performance" OR "task performance" OR "error reduction" OR "cognitive efficiency") AND (("construction industry" OR "civil engineering" OR "structural engineering" OR "geotechnical engineering" OR "hydraulic engineering" OR "transport engineering" OR "mechanical engineering" OR "plumbing" OR "sanitary engineering" OR "HVAC" OR "heating ventilation air conditioning" OR "climate engineering" OR "environmental engineering" OR "electrical engineering" OR "power engineering" OR "energy engineering" OR "lighting engineering" OR "building physics" OR "acoustical engineering" OR "thermal engineering" OR "fire safety engineering" OR "industrial engineering" OR "maintenance engineering" OR "construction management" OR "architecture" OR "urban engineering" OR "public works" OR "infrastructure engineering")))
ACM-DL	("human-machine interface" OR "human computer interaction" OR "HMI" OR "HCI") AND ("ecological interface design" OR "EID" OR "ecological design") AND ("situational awareness" OR "context sensitivity" OR "cognitive load" OR "usability" OR "mental workload" OR "user performance" OR "task performance" OR "error reduction" OR "cognitive efficiency") AND ("construction industry" OR "civil engineering" OR "structural engineering" OR "geotechnical engineering" OR "hydraulic engineering" OR "transport engineering" OR "mechanical engineering" OR "plumbing" OR "sanitary engineering" OR "HVAC" OR "heating ventilation air conditioning" OR "climate engineering" OR "environmental engineering" OR "electrical engineering" OR "power engineering" OR "energy engineering" OR "lighting engineering" OR "building physics" OR "acoustical engineering" OR "thermal engineering" OR "fire safety engineering" OR "industrial engineering" OR "maintenance engineering" OR "construction management" OR "architecture" OR "urban engineering" OR "public works" OR "infrastructure engineering")

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Base de données	Requête
Scopus	TITLE-ABS-KEY(("human-machine interface" OR "human computer interaction" OR "HMI" OR "HCI") AND ("ecological interface design" OR "EID" OR "ecological design") AND ("situational awareness" OR "context sensitivity" OR "cognitive load" OR "usability" OR "mental workload" OR "user performance" OR "task performance" OR "error reduction" OR "cognitive efficiency") AND (("construction industry" OR "civil engineering" OR "structural engineering" OR "geotechnical engineering" OR "hydraulic engineering" OR "transport engineering" OR "mechanical engineering" OR "plumbing" OR "sanitary engineering" OR "HVAC" OR "heating ventilation air conditioning" OR "climate engineering" OR "environmental engineering" OR "electrical engineering" OR "power engineering" OR "energy engineering" OR "lighting engineering" OR "building physics" OR "acoustical engineering" OR "thermal engineering" OR "fire safety engineering" OR "industrial engineering" OR "maintenance engineering" OR "construction management" OR "architecture" OR "urban engineering" OR "public works" OR "infrastructure engineering")))
ScienceDirect	TITLE-ABS-KEY(("human-machine interface" OR "human computer interaction" OR "HMI" OR "HCI") AND ("ecological interface design" OR "EID" OR "ecological design") AND ("situational awareness" OR "context sensitivity" OR "cognitive load" OR "usability" OR "mental workload" OR "user performance" OR "task performance" OR "error reduction" OR "cognitive efficiency") AND (("construction industry" OR "civil engineering" OR "structural engineering" OR "geotechnical engineering" OR "hydraulic engineering" OR "transport engineering" OR "mechanical engineering" OR "plumbing" OR "sanitary engineering" OR "HVAC" OR "heating ventilation air conditioning" OR "climate engineering" OR "environmental engineering" OR "electrical engineering" OR "power engineering" OR "energy engineering" OR "lighting engineering" OR "building physics" OR "acoustical engineering" OR "thermal engineering" OR "fire safety engineering" OR "industrial engineering" OR "maintenance engineering" OR "construction management" OR "architecture" OR "urban engineering" OR "public works" OR "infrastructure engineering")))

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Base de données	Requête
Web of Science	TS=(("human-machine interface" OR "human computer interaction" OR "HMI" OR "HCI") AND ("ecological interface design" OR "EID" OR "ecological design") AND ("situational awareness" OR "context sensitivity" OR "cognitive load" OR "usability" OR "mental workload" OR "user performance" OR "task performance" OR "error reduction" OR "cognitive efficiency") AND (("construction industry" OR "civil engineering" OR "structural engineering" OR "geotechnical engineering" OR "hydraulic engineering" OR "transport engineering" OR "mechanical engineering" OR "plumbing" OR "sanitary engineering" OR "HVAC" OR "heating ventilation air conditioning" OR "climate engineering" OR "environmental engineering" OR "electrical engineering" OR "power engineering" OR "energy engineering" OR "lighting engineering" OR "building physics" OR "acoustical engineering" OR "thermal engineering" OR "fire safety engineering" OR "industrial engineering" OR "maintenance engineering" OR "construction management" OR "architecture" OR "urban engineering" OR "public works" OR "infrastructure engineering")))

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Base de données	Requête
INSPEC	(TI=("human-machine interface" OR "human computer interaction" OR "HMI" OR "HCI")) AND (TI=("ecological interface design" OR "EID" OR "ecological design")) AND (TI=("situational awareness" OR "context sensitivity" OR "cognitive load" OR "usability" OR "mental workload" OR "user performance" OR "task performance" OR "error reduction" OR "cognitive efficiency") OR AB=("situational awareness" OR "context sensitivity" OR "cognitive load" OR "usability" OR "mental workload" OR "user performance" OR "task performance" OR "error reduction" OR "cognitive efficiency")) AND (TI=("construction industry" OR "civil engineering" OR "structural engineering" OR "geotechnical engineering" OR "hydraulic engineering" OR "transport engineering" OR "mechanical engineering" OR "plumbing" OR "sanitary engineering" OR "HVAC" OR "heating ventilation air conditioning" OR "climate engineering" OR "environmental engineering" OR "electrical engineering" OR "power engineering" OR "energy engineering" OR "lighting engineering" OR "building physics" OR "acoustical engineering" OR "thermal engineering" OR "fire safety engineering" OR "industrial engineering" OR "maintenance engineering" OR "construction management" OR "architecture" OR "urban engineering" OR "public works" OR "infrastructure engineering") OR AB=("construction industry" OR "civil engineering" OR "structural engineering" OR "geotechnical engineering" OR "hydraulic engineering" OR "transport engineering" OR "mechanical engineering" OR "plumbing" OR "sanitary engineering" OR "HVAC" OR "heating ventilation air conditioning" OR "climate engineering" OR "environmental engineering" OR "electrical engineering" OR "power engineering" OR "energy engineering" OR "lighting engineering" OR "building physics" OR "acoustical engineering" OR "thermal engineering" OR "fire safety engineering" OR "industrial engineering" OR "maintenance engineering" OR "construction management" OR "architecture" OR "urban engineering" OR "public works" OR "infrastructure engineering"))

Nous limitons la collecte d'articles à une profondeur de 10 ans soit entre le 2015-01-01 et le 2025-01-01. Seuls les articles de revues et de colloque en anglais, associés à l'interraction humain-machine sont retenus. Nous écartons les articles non revues par les pairs, les articles incomplets et ceux sans résultats empiriques. L'opération de déduplication est réalisée sur Zotero.

2.2 Processus de recherche

Recherche initiale → collecte des résultats → exportation (BibTeX, CSV). Déduplication (Zotero, EndNote, Mendeley, etc.).

Les articles sont préparés puis sélectionnés en suivant le processus présenté en figure [[. Automatique (Action tag, plugin, etc.)

Etape 1 Déduplication `(merge-entries (:where (= :DOI :Title)))`

Etape 2 Filtration `(delete-entries (:where (and (< :date "2015-01-01") (not (= :langue "en")))))`

Mannuel systématique

Etape 3 non revues par les pairs, incomplets, sans résultats empiriques.

Mannuel collégial

Étape 4 filtrage par titre et résumé.

Étape 5 filtrage par texte intégral.

Étape 3 validation inter-évaluateurs (au moins deux chercheurs).

2.3 Formulaire d'extraction

Champs obligatoires : Identifiant (ID) Référence bibliographique complète Année de publication Contexte (population, domaine, technologie) Méthodologie de l'étude Résultats principaux (Outcome) Limites rapportées

2.4 Évaluation de la qualité

Checklist PRISMA, indiquer la localisation de chaque item dans le rapport final.

Checklist qualité (exemple) : Clarté des objectifs : oui/non Méthodologie décrite : oui/non Données empiriques disponibles : oui/non Validité des résultats : élevé/moyen/faible

2.5 Schéma de sélection

Nombre d'articles identifiés, filtrés, exclus, inclus.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

3 Analysis and results

Méthodes d'analyse Quantitative (comptages, distributions, tendances temporelles). Qualitative (analyse thématique, catégorisation, taxonomie). Meta-analysis (si applicable).

4 Wrapping up

4.1 General discussion

Contribution scientifique : Lacunes identifiées Etat de l'art consolidé. Contribution pratique : Recommandations Implications pour les chercheurs et praticiens. Limites méthodologiques du protocole.

4.2 Recommendations

5 Treats to validity

Risques de biais de publication. Risques liés à l'échantillonnage ou aux bases de données. Stratégies d'atténuation (diversification, double codage).

6 Research opportunity

7 Conclusion