GLOBAL RESPONSE AGAINST CHILD EXPLOITATION

Grace

Key Exploitable Results

GRACE PARTNERS

VICOM	VICOMTECH (Coordinator)	**EUROPOL**	THE EUROPEAN UNION AGENCY FOR LAW ENFORCEMENT COOPERATION
AGS	AN GARDA SIOCHANA	**IGPR**	GENERAL INSPECTORATE OF THE ROMANIAN POLICE
BFP	BELGIAN FEDERAL POLICE	**INOV**	INOV
CENTRIC	SHEFFIELD HALLAM UNIVERSITY	**KGP**	NATIONAL POLICE HEADQUARTERS, POLAND
CERTH	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	**L3CE**	LITHUANIAN CYBERCRIME CENTER OF EXCELLENCE FOR TRAINING, RESEARCH & EDUCATION
MIRPN	SPANISH NATIONAL POLICE	**NICC**	NATIONAL INSTITUTE FOR CRIMINALISTICS AND CRIMINOLOGY
CRI	CYBERCRIME RESEARCH INSTITUTE	**PJ**	POLICIA JUDICIARIA
CYP	CYPRUS POLICE	**SYN**	SYNELIXIS
DCPJ	CENTRAL DIRECTORATE OF THE JUDICIAL POLICE, FRANCE	**ULE**	UNIVERSITY OF LEON
ENG	ENGINEERING INGEGNERIA INFORMATICA	**WEBIQ**	WEB IQ
EUC	EUROPEAN UNIVERSITY CYPRUS	**ZITIS**	THE CENTRAL OFFICE FOR INFORMATION TECHNOLOGY IN THE SECURITY SECTOR

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 883341.

CONTENTS

Grace

1 INTRODUCTION

The growth in online child sexual exploitation and abuse material (CSEM/CSAM) is a significant challenge for European law enforcement agencies. Referrals of CSEM exceed the capacity of LEAs to respond in a practical and timely manner. To safeguard victims, prosecute offenders and limit the spread of CSEM, LEAs need a next-generation AI-powered investigative platform.

GRACE applies proven techniques in machine learning to the referral and analysis process while embracing the technical, ethical and legal challenges unique to fighting CSE.

At the heart of the project, GRACE has three core concepts.

- Address the volume and analyse the content of online CSEM through technological innovations;
- Provide genuine operational value to LEAs in their investigation of online CSEM; and
- Impact at the strategic and policy level in the harmonisation of EU-wide responses to CSE.

Specifically, GRACE strives to standardise the management of CSEM referrals from Online Service Providers. The primary focus is on the National Center for Missing and Exploited Children (NCMEC) reports. The key goals are to avoid duplicate processing and enhance collaboration amongst LEAs for investigative purposes.

GRACE provides new analytics tools that process visual, audio and text data using AI techniques to produce structured and validated information. Furthermore, by developing a federated (machine) learning platform, GRACE exploits the available infrastructure and CSEM content distributed across different EU Member States for training novel neural network models.

Moreover, GRACE has provided innovative forensic tools, such as CSEM-specific content analysis and classification, content-based geo-localisation, evidence graphs to connect cases, case prioritisation techniques, and predictive analysis of trends in CSEM offenders' tactics.

GRACE has the following vision:

- By 2030, Europol and Member States' LEAs adopt the GRACE system as the state-of-the-art case management tool for CSEM-related investigations based on the information and data from NCMEC reports.

- Furthermore, the GRACE approach based upon federated learning has spurred new investigative and operational protocols and models, allowing Europol and MS LEAs to increase their investigative capabilities.

- Finally, the new data analytics and forensics tools designed and tested by GRACE will also be exploited and used as tools and solutions applicable to other domains in the Fight against Crime and Terrorism (FCT).

2 KEY EXPLOITABLE RESULTS

By the end of the project, the GRACE system and most of the individual technology components proposing new analytics and forensics tools, have reached a Technology Readiness Level (TRL) 6 and 7, following a co-creation process between technology developers and end-users (Europol and 8 LEAs). Furthermore, these results have successfully demonstrated the feasibility and adoptability of the solution in a real environment.

Nevertheless, the GRACE system and its components still need further research, development and innovation efforts to enable their uptake by end-users. Documenting and promoting the Key Exploitable Results (KERs) is essential for the project's ultimate success.

Moreover, GRACE project's KERs go well beyond the technology solutions developed and tested, encompassing results such as relevant scientific knowledge, ontologies and data harmonisation proposals, research data, good practices in the fight against CSEM and wider policy recommendations.

*A **Key Exploitable Result (KER)** is an identified main interesting result, which has been selected and prioritised due to its high potential to be "exploited" – meaning to make use and derive benefits- downstream the value chain of a product, process or solution, or act as an important input to policy, further research or education.*

These following pages document and present the current KERs within the GRACE project. As it stands, the technologies have been piloted in three separate rounds of evaluation. The last of these took place in October 2023 in Madrid, Spain, in a real-live environment in the premises of MIR-PN/Isdefe.

GRACE's KERs are described in content of the EU civil security taxonomy. Each KER refers to one or more of the products and services listed for the security functions linked to the Child Sexual Abuse sub-area within the Fighting Crime and Terrorism area (FCT).

EU CIVIL SECURITY TAXONOMY

GRACE has decided to follow the EU Civil Security Taxonomy when characterising the GRACE results. The EU Civil Security Taxonomy aims to create a common language or harmonised terminology for security products and services.

The taxonomy provides a comprehensive and detailed reference for security products and services built around different levels of aggregation: the four security areas (L1) with their respective sub-areas (L2 and L3), as well as the security functions that a given product or service enables or supports (i.e., functional areas). It can be considered as a first, actionable step towards the development of one formal, recognized taxonomy of security technologies. The taxonomy can be used to support the process of articulating a capability-driven approach within the civil security sector in the European Union.

L1 Security Area

Fight against Crime and Terrorism

L2 Sub Area

Cybercrime

L3 Sub Area

Child Sexual Exploitation

Security Functions

Data, information & intelligence gathering management and exploitation

Positioning and localisation, tracking and tracing

Monitoring and surveillance of environment and activities

Investigation and forensics

Security of information systems, networks and hardware

Secure and public communication, data and information exchange

Identification and authentication of persons, assets and goods

Training and exercises

Detection of goods, substances

EU Civil Security Taxonomy: https://home-affairs.ec.europa.eu/networks/ceris-community-european-research-and-innovation-security/eu-security-market-study/eu-civil-security-taxonomy-and-taxonomy-explorer_en

3 Technical KERs

3.1 DATA ACQUISITION AND STORAGE

DATA HANDLING FRAMEWORK

Partner: INOV
TRL 6

The data handling framework combines five KERs that automatically and sequentially perform the steps required for acquisition and preprocessing. The combined KERs provide the following functions.

- **Data Ingestion** – Enables acquisition of NCMEC and NCEC reports through REST APIs and provides a client for services to submit CSE-related data to GRACE.
- **Data Cleansing** – Prepares data for storage through a series of preprocessing operations.
- **Semantic Mapping** – Maps elements in the data to specific entities and attributes in the ontology.
- **Metadata Catalogue** – A set of services that act as a single access point to the semantic data stored in the triplestore supporting data validation.
- **Ontology Query Service** – A service that provides access to data based on the ontology via an API.
- **Storage Management** – A module providing data management, including access control and encryption of data at rest.

TARGETED CRAWLER

Partner: WebIQ
TRL 6 (OSINT)
TRL 9 (IRIS)
TRL 6 (Targeted crawler)

The targeted crawlers acquire data from open sources using a targeted and privacy-aware approach. Their purpose is to support officers when they need to check online information. The crawlers are divided into three linked modules,

- **OSINT Module** – Integration of the IRIS online investigation software with the GRACE data acquisition pipelines in the data handling framework.
- **IRIS Software** – An online data acquisition engine to run online investigations.
- **Targeted Online Investigations** – An extension of the IRIS software that supports targeted crawling and online data acquisition, including page navigation and text analysis.

WATERMARKING

Partner: NICC
TRL 4

Watermarking aims to make the results from the GRACE platform admissible in court. This approach verifies that no GRACE output data has been tampered with after being exported from the system.

The watermark is visual and explicit. It contains a QR code that users can use to download a verification code (SHA256 hash) for the exported resource from GRACE.

CHAIN OF CUSTODY

Partner: NICC
TRL 5

This module records all activities in the GRACE platform in a secured log, enabling the reproducibility of any processing results.

For each tool executed, the module logs its input, output, parameters, configuration, and system context data or meta-data with a secure timestamp.

HASHING AND DEDUPLICATION

Partner: NICC
TRL 5

The hashing and deduplication module is responsible for generating, verifying, storing, and searching binary hashes (MD5, SHA1, SHA256) and robust hashes (PHash, DHash, PDQ).

It comprises additional functionalities for detecting duplicated entries based on the values of the computed hashes.

SYNTHETIC REPORT GENERATOR

Partner: INOV
TRL 6

The synthetic report generator provides various mechanisms to generate template-based synthetic CSE reports.

The functionality includes generating single reports, selecting the attached media files, or an arbitrary number of reports. The content of each report is chosen randomly from a dedicated pre-prepared dataset aligned to the test case.

3.2 ANALYSIS ENRICHING TECHNOLOGY - TEXT

NAMED ENTITY RECOGNITION

Partners: VICOM and L3CE
TRL 6

The Named Entity Recognition tool aims to detect and classify sequences of words as being certain entity types. Unlike text classification, which classifies full pieces of text (i.e., documents), a sequence labelling tool labels individual words/tokens from a sequence. These labels indicate whether such words are part of an entity and the entity type according to predefined vocabulary.

CSEM FILE NAME CLASSIFICATION

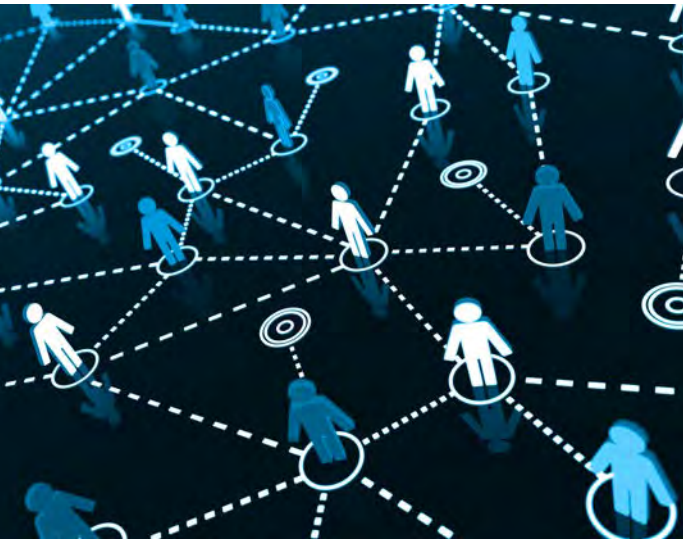
Partner: ULE
TRL 6

This module aims to identify CSEM-related files based on the file name and the absolute file path, without addressing the file contents. The software currently uses a dataset of CSEM-related file names and non-CSEM files names for training. Based on a test set, the software has an accuracy of greater than 92%. For each input file name, the module predicts the category of the file and a confidence score.

SENTIMENT ANALYSIS

Partner: ULE
TRL 6

The sentiment analysis module identifies whether the input text is related to CSE activity. It receives an input text, normalises it, and passes it into a supervised classification model to identify the category of the text. The model will assign the input text a label referring to its category (i.e., CSEM or not CSEM) and a confidence score indicating the confidence that the prediction is correct.



SEMANTIC RELATIONSHIP EXTRACTOR

Partner: ENG
TRL 6

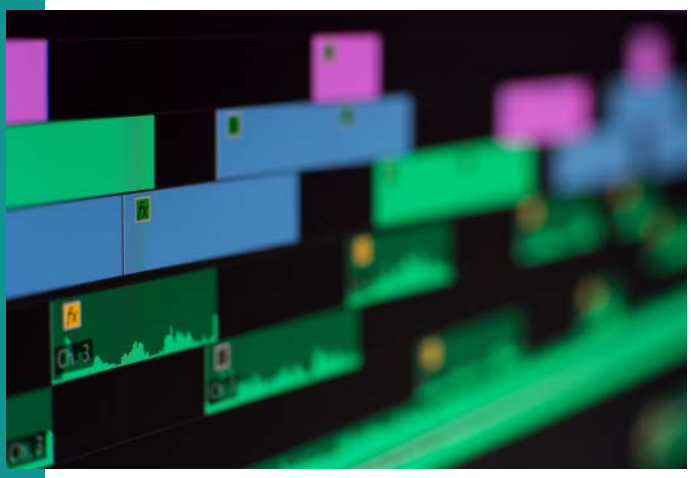
The Semantic Relationship Extractor extracts relationships between entities mentioned in a text. The entities currently supported are PEOPLE, LOCATION and ORGANISATION. Relationships given as results of the processing are represented as triples in the format <subject, verb, object>.

GERMAN DIALECT DETECTION

Partner: ZITIS
TRL 4

The module provides German dialect classification for text data using a pre-trained model. The package consists of a command line tool for classifying custom text data with pre-trained models based on the GDI dataset, which covers four Swiss German dialects (Basel, Bern, Zurich and Lucerne). The package also includes support to train your own model using custom training data.

3.3 ANALYSIS ENRICHING TECHNOLOGY - VISUAL MEDIA



VISUAL TAMPERING DETECTION

Partner: CERTH
TRL 6

This software provides algorithms for the detection of images/videos that have been altered using deep-faking methods. The aim is to ensure the integrity of digital video by verifying that the video has not been tampered with.

IMAGE TAMPER DETECTION

Partner: ULE
TRL 6

This software identifies if an input image has been tampered with and attempts to localise the tampered area. The tool can detect images modified by copy-paste, splicing, or object-removal actions. It returns the coordinates of a bounding box around the tampered area and a confidence score of the prediction. The model has an accuracy of 80% on a test set.

IMAGE FORGERY DETECTION & CAMERA CROSS-MATCHING

Partner: NICC
TRL 3 (Forgery)
TRL 4 (Camera matching)

This module detects forged images manipulated via various image modification operations. Photo Response Non-Uniformity (PRNU) is a noise generated during acquiring an image considered unique for each camera sensor, resulting in a camera fingerprint.

The module permits the extraction of the PRNU fingerprint from a set of pictures or frames extracted from a video file. The module can detect areas where the expected camera fingerprint is absent, indicating a possible manipulation after acquiring the image/video. For camera cross-matching, the camera fingerprint can be matched across photographs.

VIDEO ENHANCEMENT

Partner: CERTH
TRL 6

This tool takes as input a Low Resolution (LR) video clip and outputs a reconstructed High Resolution (HR) (x4) version. The module uses a multi-frame approach to exploit extra information by processing consecutive frames.

DETECTION AND RECOGNITION OF OBJECTS

Partner: CERTH
TRL 6

This software estimates the presence of relevant objects in an image. It receives either an image file or a URL. After processing the image using neural networks, it returns each detected object's location and score.

OBJECT RETRIEVAL BY EXAMPLE

Partner: ULE
TRL 6

The software retrieves similar objects to a given example, named query, from a database of images. The object retrieval is performed using the proposed SBQE(NE-C) model, which uses a colour neural descriptor (NE-C) and a stride-based query expansion technique (SBQE) to retrieve similar objects. The software returns a list of images sorted according to the similarity score with the query object.

SCENE TEXT DETECTION AND UNDERSTANDING

Partner: CERTH
TRL 6

This module identifies and recognises text in images under various scenarios, i.e., text in the wild. The detected text is transcribed into the best-matching language from a set of integrated languages and alphabets.

MEME CLASSIFICATION

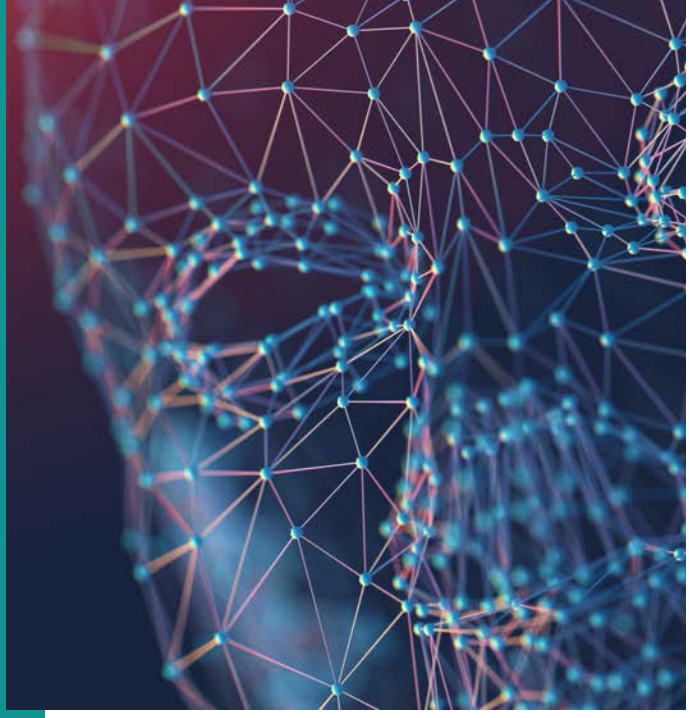
Partner: ULE
TRL 6

This module identifies if an image is a meme or not. The model is based on the Vision Transformers model that was trained on public datasets of meme and non-meme images.

IMAGE/VIDEO BASED GEO-LOCALISATION

Partner: CERTH
TRL 5

The module suggests possible countries that appear in the image or video content to support decision-making and linkage to other cases. The suggestions are based on the overall image as well as certain parts/objects that appear in the image or video frame(s).



BODY PART DETECTION

Partner: VICOM
TRL 4

Person body part detection uses pose estimation or body part segmentation to identify different body parts from an image. The aim is to partition persons in the image into multiple semantically consistent regions (e.g., head, arms, legs) using cross-domain complementary learning. It detects body parts macroscopically at a low granularity level.

FACE DETECTION AND RE-IDENTIFICATION

Partner: VICOM
TRL 6

This tool detects faces in video feeds and extracts identity vectors to communicate them to other services for successful re-identification.

Approaches to tackling occlusions, such as wearing a nose-mouth mask, artificially adding eye black boxes, and others are also considered.

PERSON DETECTION AND RE-IDENTIFICATION

Partner: VICOM
TRL 6

This tool detects persons in video feeds, extracts, and communicates regions of interest to other services for person re-identification.

Person re-identification extracts a unique person descriptor that can then be used for crosschecking the re-occurrence of the person within an existing database.

AGE AND GENDER ESTIMATION FROM FACES

Partner: ULE
TRL 6

The software estimates the age and gender of people present in an image by analysing the features of their faces. The software returns four values: an integer corresponding to the estimated age between 0 and 100 (years), a confidence score for the estimated age, a class corresponding to the estimated age category (i.e., pre-pubescents, pubescents, or adults), an integer corresponding to the estimated gender (i.e., 0, male; and 1, female), and a confidence score for the estimated for both.

VIDEO CAPTIONING

Partner: CERTH
TRL 6

This software extracts textual descriptions from videos. It processes a video file or a URL using deep neural networks, returning a caption in JSON format.

VIDEO SCENE DETECTION

Partner: NICC
TRL 5

This module detects the individual scenes that constitute a video. It splits the original video into the previously detected fragments and produces animated pictures summarising the extracted segments.

CSE IMAGES CLASSIFICATION BASED ON SEVERITY

Partner: ULE
TRL 6

The software classifies input images into four categories based on the severity of their content: non-relevant material, nudity, sexual activity, and paraphilias. The software returns an integer corresponding to the predicted image content severity and a confidence score.

TATTOO AND SCAR DETECTION

Partner: CERTH
TRL 6

This software estimates the presence of tattoos/scars in an image. It receives either an image file or a URL. After processing the image using neural networks, it returns the location and score of each detected tattoo or scar.

VIDEO SUMMARISATION BASED ON FACES

Partner: ULE
TRL 6

Based on the perceptual hashing technique, the software creates a video summary that includes keyframes (distinctive scenes) with people's faces. The software returns a list of visually representative frames that include people's faces.

3.4 ANALYSIS ENRICHING TECHNOLOGY - AUDIO

AUDIO SPEECH RECOGNITION AND KEYWORD SEARCH

Partner: VICOM
TRL 6

The Automatic Speech Recognition Tool transcribes speech utterances in an audio signal into text. The Keyword Spotting Tool detects keywords in audio and enables indexing of conversations to be queries against words of interest.

SPEAKER DIARISATION

Partner: ULE
TRL 6

Speaker identification identifies the speaker based on their voice and whether they are participants or narrators. Speaker re-identification identifies pieces of content containing the same actors. The software receives input audio and the number of speakers present. It returns a list of audio segments per speaker, representing the time each speaker spoke, forming the diarisation. The software comprises several models, including voice activity detection, overlap detection, speaker change detection, voiceprint generation, and speaker verification.

SPEAKER COMPARISON

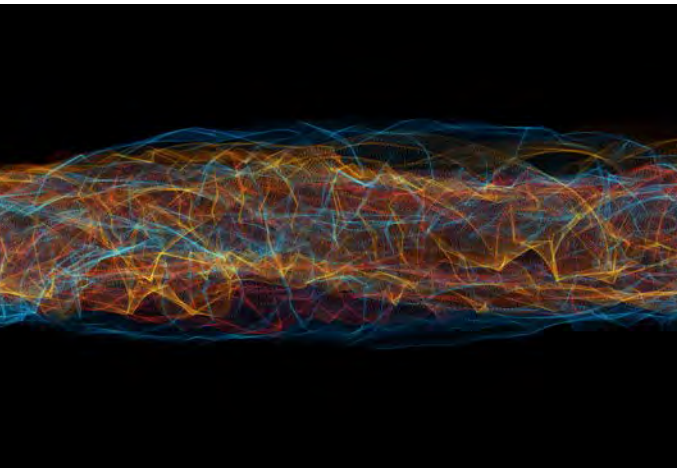
Partner: ULE
TRL 6

The speaker comparison module compares two audios and verifies whether the voice in both audios belongs to the same or different person.

LANGUAGE IDENTIFICATION

Partner: ULE
TRL 6

The language identification component recognises a speaker's language from a set of pre-learned languages. It uses an end-to-end approach that performs all operations within a machine-learning model. The tool supports the following languages: English, Spanish, Italian, French, Portuguese, German, Russian, and Greek. An updated version of the model can support 107 languages.



AGE ESTIMATION BASED ON AUDIO

Partner: ULE
TRL 6

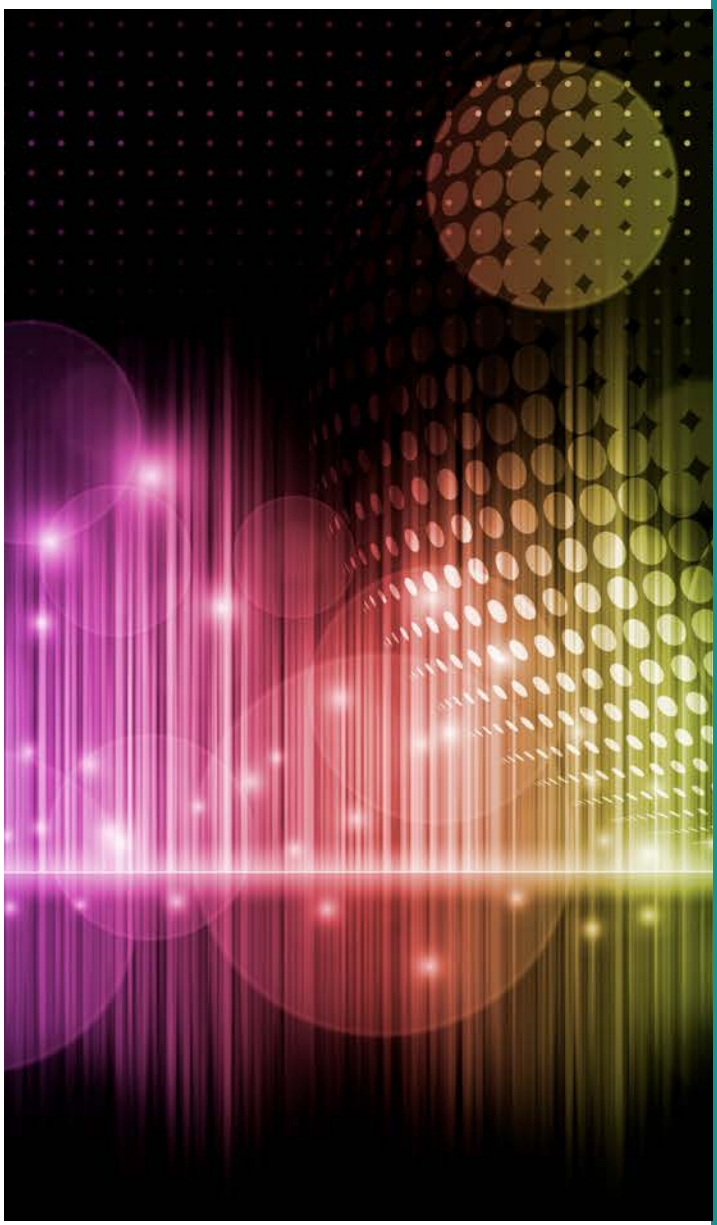
The software performs age and gender estimation based on audio. The software receives as input an audio file containing a single speaker and predicts the gender and the age of the speaker.

DIALECT / ACCENT DETECTION

Partner: ULE
TRL 6

This software identifies the accent of the voice present in an input audio from a set of pre-learned accents. The accent may correspond to a country of origin or a native language.

Each language has a different model specialised in the accents of that specific language. The supported languages are Spanish, English, German and Portuguese.



BACKGROUND AUDIO ANALYSIS

Partner: ULE
TRL 6

The background audio analysis tool automatically amplifies and extracts the background noises from pre-learned acoustic events and their time intervals.

The software can identify 527 acoustic events and works as a multi-label classification machine learning model.

3.5 ANALYSIS ENRICHING TECHNOLOGY - INTELLIGENCE TOOLS

ENTITY CROSS-MATCHING AND MAPPING

Partner: CENTRIC
TRL 5

Cross-Matching finds suspects and victims across NCMEC referrals that are linked. It does this through pre-configured rules based on factual indicators from the NCMEC data including fields such as email or username etc. These fields are combined to create the rule that then creates links between related suspects to help enrich LEAs' investigations.

TREND DETECTION

Partner: CENTRIC
TRL 6

Trend detections runs automatically as NCMEC referrals flow into the system. It identifies key data that will be collated and analysed to provide visual outputs in the form of timeline graphs to track the data contained within the system. This also enables the automatic identification of short- and long-term trends which can be used by investigators to find patterns in referrals.

PRIORITISATION

Partner: CENTRIC
TRL 6

The Prioritisation tool uses a set of rules based on indicators from NCMEC data and GRACE analysis module outputs. These rules were created in collaboration with MS LEA to give each incoming referral a priority indicator (Low, Medium, and High).

The module is fully configurable to allow for accurate and effective prioritisation to identify the most critical referrals.

DATA FUSION

Partner: ENG
TRL 6

This module performs reasoning processes and pattern identification. The module aims to suggest new knowledge about potential matches between entities and dangerous behavioural patterns by defining strategies that can support the process of knowledge enrichment by producing suggestions.

ORCHESTRATION FRAMEWORK

Partner: ENG
TRL 6

The orchestration framework enables the creation of pipelines composed of a chain of tools. The software aims to have an efficient modular system that is able to integrate and connect heterogeneous components and produce results as a composition of services.

3.6 FEDERATED LEARNING

IMAGE / VIDEO ANNOTATION TOOL

Partner: VICOM
TRL 7

The image and video annotation tool is an end-user web-based application for manual annotation of information observable in images and videos. It enables the labelling of complex scenes and multi-variate characteristics of objects and events captured within images and videos.

FEDERATED LEARNING SECURITY MECHANISMS

Partner: SYN
TRL 6

Building a federated learning environment with guaranteed security and privacy. This is an extension of the federated learning framework that provides methods that enable the configuration of privacy-preserving mechanisms.

FEDERATED LEARNING INFRASTRUCTURE AND PLATFORM

Partners: VICOM, CERTH, SYN
TRL 6

The federated learning platform consists of tools and processes that govern the distributed learning of models, with privacy-preserving features that ensure end-users only have limited access to training data, i.e., federated learning.

The infrastructure, tool set up and the federated learning task management (planning, execution and control) are part of the solution. The framework provides for secure and private deep learning, allowing training over a remote session.

SEMI-AUTOMATED DATA ANNOTATION TOOL

Partner: SYN
TRL 7

The semi-automated data annotation framework operates with various data modalities (i.e., text, imaging, audio) and is based on integrating tools, such as Label Studio, to retain machine learning models by refining pre-annotated data.

3.7 GRACE SYSTEM

Partner: All technical partners
TRL 6

SYSTEM STRUCTURE

The GRACE system integrates the various modules, pipelines, workflows, and security functions developed across the system into a single framework. The motivation for developing an integrated system is to support the storage and preservation of security and evidentially sensitive data, as well as link together multiple processing steps into workflow chains. The system provides access for both Europol and MS LEAs investigators.

A single system also enables, at the platform level, the ability to implement chain of custody management approaches that also satisfy data retention regulations. The system also facilitates an efficiency of process that minimises the need for LEAs to migrate data between different applications, which decreases the opportunity for errors.

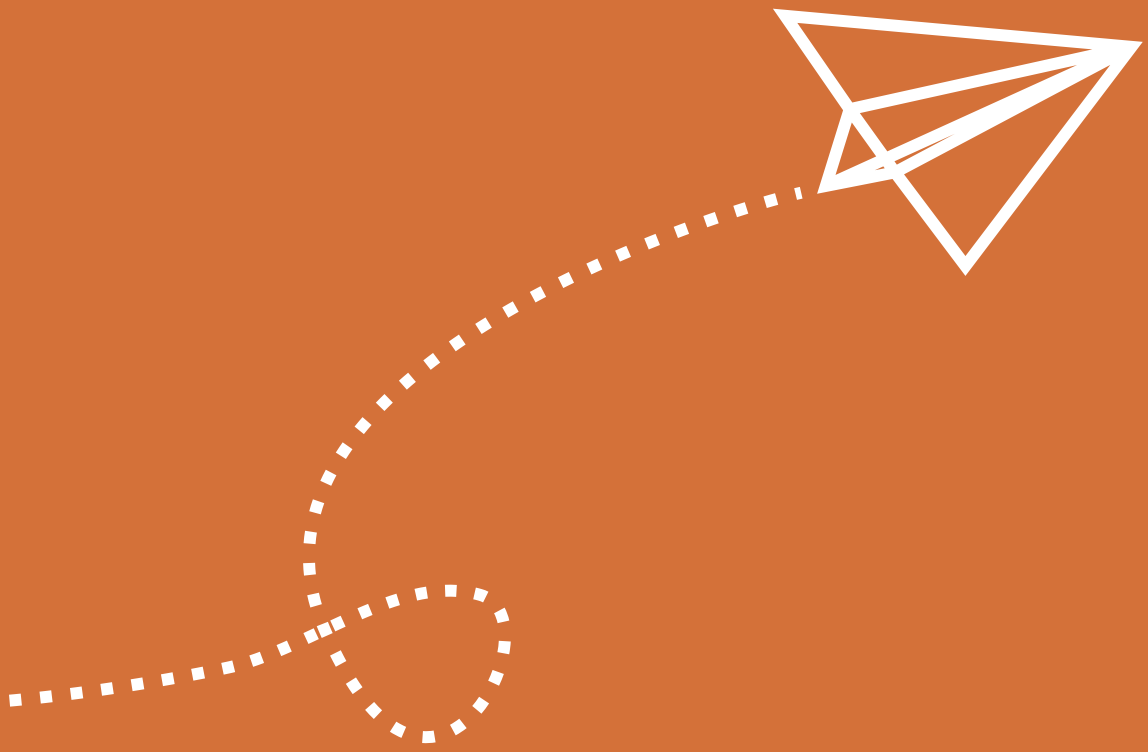
Finally, the overall system provides user interfaces that ease the use of different components, as well as various management and adminstrative functions that enhance organisational use.

WORKFLOWS

Partners: CERTH, CENTRIC, ENG, INOV, SYNULE, VICOM
TRL6

GRACE System implements workflows that can speed up investigations and increase the efficiency of prioritisation actions.

Workflow chains usually start with an image of text input from a referral followed by the application of one or more processing tools. The outputs of this analysis is then passed to the prioritisation engine to quickly assess the urgency of any required follow up.



4 Non-Technical KERs

4.1 SCIENTIFIC PUBLICATIONS

GRACE has published several scientific articles that advance the state-of-the-art in computer science and other domains.

- Adler, A., Geierhos, M., & Hobley, E. (2021). Influence of Training Data on the Invertability of Neural Networks for Handwritten Digit Recognition. In *2021 20th IEEE International Conference on Machine Learning and Applications (ICMLA)* (pp. 730-737). IEEE.

- Montero, D., Nieto, M., Leskovsky, P., & Aginako, N. (2022). Boosting masked face recognition with multi-task arcface. In *2022 16th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)* (pp. 184-189). IEEE.

- Al-Nabki, W., Fidalgo, E., Alegre, E., & Alaiz-Rodriguez, R. (2023). Short text classification approach to identify child sexual exploitation material. *Scientific Reports*, 13(1), 16108.

- Al-Nabki, W., Vasco-Carofilis, A., Díaz-Ocampo, D., Chaves, D., Fernández-Robles, L. & Alegre, E. (2023). Multi-label Text Classification Approach for User Profiling in Chat Messages. *5th International Conference on Applications of Intelligent Systems (APPIS)*, Las Palmas de Gran Canaria, Spain.

- Chaves, D.; Agarwal, N.; Fidalgo, E. and Alegre, E. (2023). A data augmentation strategy for improving age estimation to support CSEM detection. In *Proceedings of the 18th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2023)* - Volume 5. 692-699.

- Carofilis, A., Alegre, E., Fidalgo, E., & Fernández-Robles, L. (2023). Improvement of accent classification models through Grad-Transfer from Spectrograms and Gradient-weighted Class Activation Mapping. IEEE/ACM Transactions on Audio, Speech, and Language Processing. DOI: https://doi.org/10.1109/TASLP.2023.3297961

- Carofilis, A., Fernández-Robles, L., Alegre, E., & Fidalgo, E. (2023). MeWEHV: Mel and Wave Embeddings for Human Voice Tasks. *IEEE Access*.

- Díaz-Ocampo, D., Al-Nabki, W., Vasco-Carofilis, A., Fernández-Robles, L., Fidalgo, E., & Alegre, E. (2023). Authorship identification in text documents using BERT and POS features. *5th International Conference on Applications of Intelligent Systems (APPIS)*, Las Palmas de Gran Canaria, Spain.

- Gangwar, A., González-Castro, V., Alegre, E., & Fidalgo, E. (2023). Triple-BigGAN: Semi-supervised generative adversarial networks for image synthesis and classification on sexual facial expression recognition. *Neurocomputing*, 528, 200-216.

- Jeuland, E.D., Del Río Ferreras, A., Chaves, D., Fidalgo, E., González-Castro, Alegre, E. (2022) Assessment of age estimation methods for forensic applications using non-occluded and synthetic occluded facial images. *XLIII Jornadas de Automática: libro de actas*, pp.972-979.

- Psaltis, A., Patrikakis, C. Z., & Daras, P. (2022). Deep Multi-Modal Representation Schemes For Federated 3D Human Action Recognition. In *European Conference on Computer Vision* (pp. 334-352). Cham: Springer Nature Switzerland.

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PUBLIC DELIVERABLES

Recent and open access publications are available on our Zenodo Community

Currently, 11 GRACE deliverables are available online. Following the completion of the project and evaluation from the European Commission the remaining deliverables will be available on the GRACE website and CORDIS.

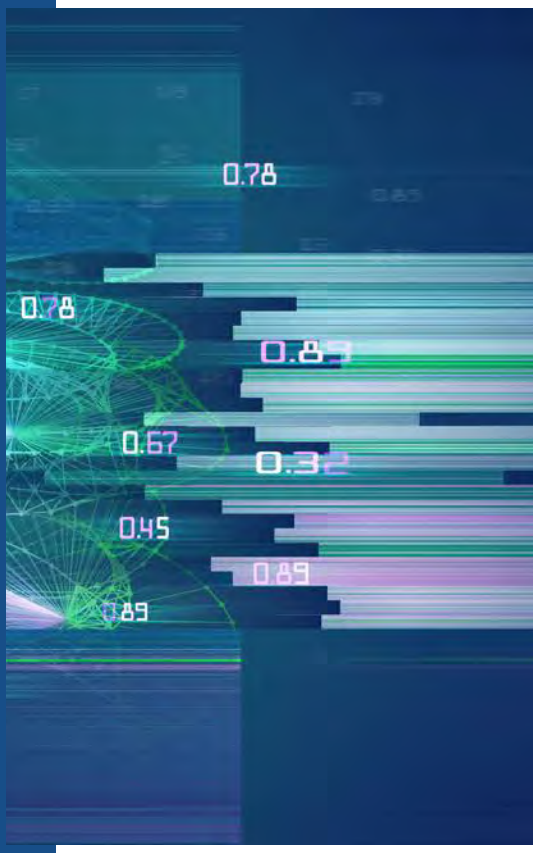
- D1.2 Quality Management Guidelines (link)
- D1.4 SELP Giudelines for GRACE (link)
- D1.5 GRACE subcommittees and Advisory Board's plan and establishment (link)
- D1.6 Innovation Management strategy, guidelines and tools (link)
- D5.3 Report on Federated Learning strategies
- D9.1 Ethical report v1 (link)
- D9.2 Ethical report v2
- D9.3 Legal Report v1 (link)
- D9.4 Legal Report v2
- D9.5 Overall legal and ethical framework v1 (link)
- D9.6 Overall legal and ethical framework v2
- D9.7 Architecture for technical safeguards – "security and privacy by design" v1 (link)
- D9.8 Architecture for technical safeguards – "security and privacy by design" v2
- D9.9 Review Mechanism and Procedure
- D10.2 GRACE website, social media presence and dissemination materials (link)
- D10.6 Stakeholder and policy recommendations for addressing online CSEM v1 (link)
- D10.7 Stakeholder and policy recommendations for addressing online CSEM v2
- D10.8 Best Practices on Victim support for LEA first responders v1 (link)
- D10.9 Best Practices on Victim support for LEA first responders v2

PUBLIC REPORTS

- Guidelines for First Responders in Child Sexual Abuse and Exploitation Cases (Europol - Public version)

A restricted version is available to LEAs by contacting Europol

4.2 RESEARCH DATASETS



BENCHMARKING DATASETS

GRACE has designated several existing public datasets as suitable for benchmarking of models by Europol and LEAs.

- Super video resolution | **REDS** | Clear and blurred images with persons, faces and texts | Image & Video
- Person detection & reidentification | **MSMT17** | Multi-scene multi-time person | Image & Video
- Face occlusion, blurring, age/gender balance | **VGGFace2** | Face images for age & gender | Image & Video
- Scene text detection | **ICDAR2019** | Scene text detection images | Image & Video
- Video summarisation based on faces | **Lonelygirl15 Season One** | Indoor videos of girls and boys talking to a camera | Image & Video
- Named Entity Recognition | **Emerging Entities 17** | English text annotated from YouTube, Stack Overflow, Twitter and Reddit | Text
- Visual tampering detection | **MISD** | Tampered images, generated using crop-and-paste operation | Image
- Deep fake detection | **FaceForesincs+++** | Original video sequences manipulated with four automated face manipulation methods | Image & Video

AUGMENTED DATASETS

GRACE has augmented several existing public datasets with additional information in order to make them more useful for the training of models in the GRACE domain.

- Age and gender estimation purposes by face occlusion, blurring, age/gender balance (ULE)
  - **UTKFace** | Face images for age & gender | Image & Video
  - **APPA-REAL** | Face images with real and apparent age labels | Image & Video
  - **AgeDB** | Face images with age and gender | Image & Video
  - **IMDB-WIKI** | Face images with age and gender | Image & Video
- Tattoo detection by blurring (CERTH) | **DeMSI** | Tattoo images | Image & Video
- Object detection and recognition by blurring (CERTH) | **NYU Depth V2** | Indoors scenes videos | Image & Video
- Viral image detection (ULE)
  - **Memes templates 2018** | Memes | Image & Video
  - **TextOCR** | Text extraction from images | Image & Video
- Noises, audio events, pitch and speed perturbation effects, childish speech; balanced age and gender; keywords related to CSEM (VICOM)
  - **Mozilla CommonVoice** | Voice corpora in English, German, French, Spanish, Italian, Portuguese and Polish | Audio
  - **Spoken Wikipedia Corpus** | Voice corpora in English and German | Audio
  - **MediaSpeech** | Voice corpora in French and Spanish | Audio
  - **Polish Parliamentary corpus** | Voice corpus in Polish | Audio
  - **VoxForge** | Voice corpora in German, French, Spanish, Italian, Portuguese | Audio
  - **Polish Parliament** | Voice corpus in Polish | Audio
  - **MUSAN** | Music, speech and noise dataset | Audio

- Speaker identification purposes, with pitch and speed perturbation, addition of background audio, addition of background noise, addition of audio events, and a combination of the above perturbations (ULE)
  - **VoxCeleb1** | Voice corpus in English | Audio
  - **VoxForge** | Voice corpora in German, Dutch, French, English, Greek, Italian, Portuguese, Russian, Spanish, Ukrainian | Audio
  - **Mozilla CommonVoice** | Voice corpora in English and Spanish | Audio
  - **L2 Artic** | German and Portuguese dialects | Audio
  - **Google Speech resources (Latin America corpora)** | Portuguese dialects | Audio
  - **NISP** | Voice corpus in English | Audio
- Audio event classification balancing classes relevant to CSEM (ULE) | **AudioSet** | Ontology of audio event classes and human-labeled 10-second sound clips from YouTube | Audio
- Relation extraction purposes by adding noise to text (ENG) | **DocRED** | English annotated text dataset constructed from Wikipedia and Wikidata | Text
- Sentiment analysis by adding noise (ULE) | **DUTA** | Web domains scraped from the Tor network divided into suspicious (illegal) activities and normal (legal) activities | Text

ANNOTATED OPERATIONAL DATASETS

A number of annotated operational and domain-relevant datasets have been produced in the framework of the project by Europol and LEAs.

4.3 CSEM TAXONOMY AND ONTOLOGY

Partner: EUROPOL

Given the importance of interoperability with respect to data across the GRACE project, the need for semantic interoperability was established
and realised through a common taxonomy and ontology.

The GRACE core ontology is composed of three core areas: LEA FACT ontology, LEA Intelligence ontology, and Europol-specific tools.

4.4 ETHICAL AND LEGAL FRAMEWORK AND GUIDELINES

Partner: CRI

LEGAL FRAMEWORKS

The complex patchwork of legal frameworks covering national and international legislations are extensive. GRACE has meticulously analysed the international CSEM legislation covering the following aspects.

- Cross-border cooperation and exchange of evidence
- International standards and restrictions on access to CSEM
- EU framework on preventing and combatting of child sexual abuse
- EU proposal for an Artificial Intelligence Act
- Victims' Rights established by the United Nations, Council of Europe and European Union
- Research and operatinal impacts of data protection legislation
- Challenges for the access to electronic evidence in the case of CSEM
- Availablilty of CSEM databases for law enforcement
- Legal implication of the use of online crawlers to investigate CSEM
- Potential impacts of the Cyber Resilience Act
- Recommendations for future actions.

These were complemented by several national reports from Slovenia, Cyprus, Portugal, Germany and Lithuania.

LEGAL AND ETHICAL GUIDELINES

Practical recommendations on the following elements related to the design, development and implementation of the GRACE system.

- Human agency and oversight
- Technical robustness and safety
- Transparency
- Diversity, non-discrimination and fairness
- Societal and environmental well-being
- Accountability
- Data governance ensuring privacy and data protection
- National legal and technical requirements for admissability and acceptability as evidence
- Privacy and best practices in the design of databases
- Integration and the use of automated searches in online investigations.

4.5 POLICY RECOMMENTATIONS

A number of actionable insights and guidelines are produced in the framework of GRACE in the fight against CSE, as well as stakeholder and policy recommendations for addressing online CSEM, and best practices on victim support for LEA first responders.

Partner: EUROPOL

STAKEHOLDER AND POLICY RECOMMENDATIONS

The uptake of GRACE stakholder and policy recommendations can have a significant impact on the holistic approach in the fight against child sexual exploitation and abuse.

GRACE has made the following recommendations.

- Implementation of currently existing EU legislation, namely Diretive 2011/93/EU, across all EU MS.
- National strategies encompassing crucial statistical and trend comparisons, including common standards for data collection and reporting.
- Invention, innovation and solution focused technology to assist LEAs in performing their tasks
- Awareness of different trends, threats and harms against children's safety, including opening of a discourse for the development of a taxonomy of online harms to protect childrens' rights at European and MS levels.
- Promote victim and offender-centric approaches
- Provide support and allocate relevant resources to law enforcement
- Prevention and awareness raising
- Prioritise childrens' participation in matters affecting them.

BEST PRACTICES ON VICTIM SUPPORT FOR LEA FIRST RESPONDERS

GRACE has also produced several guidelines to support first responders on encountering a (potential) victim of CS including,

- Usage and awareness of the appropriate terminology and definitions of first responders, child, victim and survivor, CSEM and CSAM, trauma, and child-centred and trauma-informed practicies.
- Recognising the rights of the (child) victim and ensuring their best interets are the primary concern of the first responder.
- Familiarise themselves with the 5F's in trauma: fight, flight, freeze, flop and friend.

GRACE has aslo devised five scenarios that first responders may encounter with corresponding guidance on potential courses of action.

Building on these scenarios, CENTRIC has developed a prototype serious game to support first responders' training allowing them to test their approach.

4.6 TRAINING MATERIALS

FIRST RESPONDER GUIDELINES

Partner: EUC, Europol, CENTRIC

Education and Training of LEAs can benefit from the knowledge generated within GRACE in order to update and finetune the current training programmes aimed at LEAs. GRACE has developed several training packages working alongside the projects core activities.

- Video training materials
- Serious game embedded as part of ECTEG's eFirst project
- Animated serious game focused on first responder search guidelines

Partner: EUC

TRAINING ON GRACE PLATFORM CAPABILITIES

A series of training videos that both educate the interested user on the transformative potential of AI and federated learning in driving forward-thinking solutions across industries and navigate through the great capabilities of the GRACE solutions.

- **Why we need AI?** The opening video demystifies why AI is not just an advancement in technology but a fundamental shift in how we process information, make decisions, and automate tasks for a smarter future.

- **How AI works?** In a follow-up video, viewers gain insights into how these intelligent systems learn, adapt, and evolve, transforming data into actionable intelligence.

- **What is federated learning and why we need it?** Venturing into the domain of federated learning, this installment explains the concept and its significance. As we steer towards a more privacy-conscious world, federated learning emerges as a pivotal technology enabling collaborative machine learning without compromising data security.

The videos regarding GRACE platform, provide a vivid and inviting explanation of what viewers can expect from the platform.

- **Introductory Video** - Navigating GRACE Platform. Dive into this foundational video that offers a comprehensive overview of the GRACE Platform.

- **The GRACE Pipelines**. A detailed video about the several tools the GRACE platform offers through a step by step meticulously demonstration of specific pipelines.

- **Harmonizing Data - Cross-Matching**. Explore the power of connection in our specialized video on cross-matching. Learn how our tool correlates diverse datasets to uncover valuable insights in an optimum manner.

- **Strategic Focus - Prioritization**. The video on prioritization, acts as a guide which illuminates the methodologies employed by the GRACE tools to sort and prioritize data.

- **The Collaborative Platform**. This video highlights the collective capabilities of the GRACE platform.

Grace

5 Interested?

WHAT'S NEXT?

The GRACE project and partners are committed to continuing the fight against child sexual exploitation and are considering various exploitation routes to achieve this. LEAs who are interested in any of the KERs described in this brochure are invited to contact the GRACE project or the individual partners to explore opportunities to utilise the tools developed within the project. With new CSE legislation on the horizon and the proposal for a new EEuropean Centre against Child Sexual Abuse the importance and continued innovation and development of technologies that support the detection of CSEM will be vital.

Furthermore to improve uptake of security research results, GRACE has identified the following recommendations:

- Continue to evolve innovation uptake schemes to support 'last mile' development
- Make exploitation of KERs from R&I activities easy for end-users
- Provide technical KERs to to the EU Centre to support the detection and reporting of online CSEM by hosting providers
- Transfer the results to other domains that address the fight against crime and terrorism
- Embrace the Europol sandbox approach for improved training and testing of AI models with real data

"The capabilities of automating and optimising the workflow and prioritising NCMEC referrals are being used as guidance and prototypes in other Europol actions, such as EU-CARES – a newly launched improvement initiative of Europol's services to the LEA community combating CSE."

CONTACTS

For general information or to reach out the GRACE project or the whole GRACE platform contact: **info@grace-fct.eu**

GRACE Partners' can be contacted about individual key results directly using the contacts below. For **SYN** please use the GRACE contact information.

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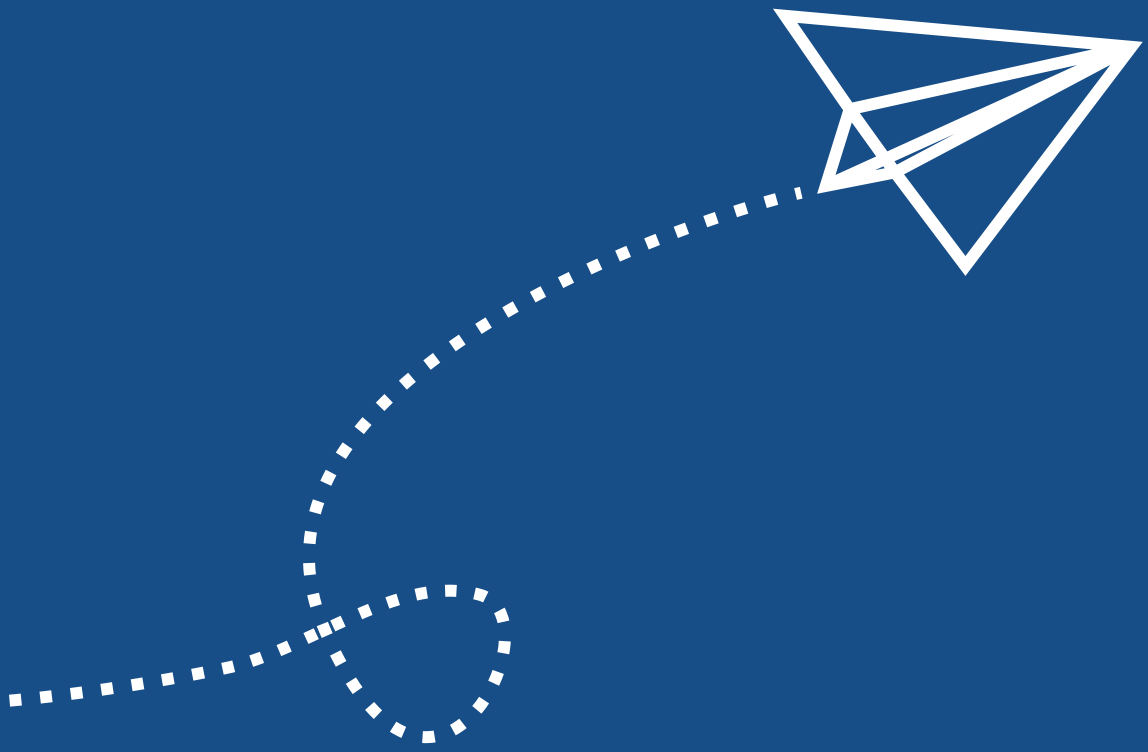

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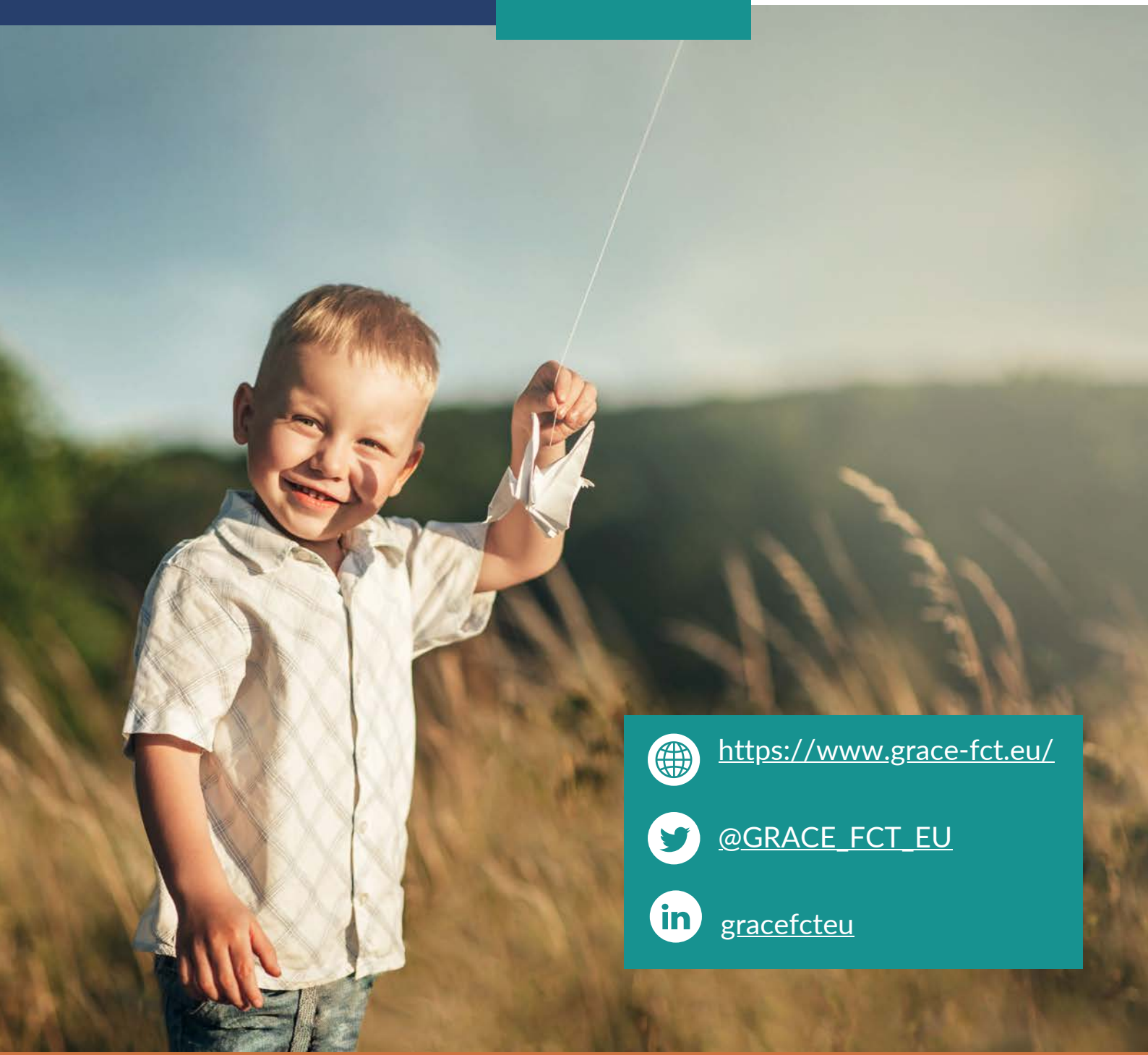
Further information



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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement Number 883341.