Escuela Técnica Superior de Ingenieros Informáticos

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Extracción de eventos jurídicos

Trabajo Fin de Máster

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RESUMEN

La extracción de información es una de las principales áreas de estudio dentro de la Inteligencia Artificial. Esta tarea se centra en derivar información estructurada a partir de un documento no estructurado o semi-estructurado utilizando para ello técnicas de procesamiento del lenguaje natural (NLP). Estos documentos pueden ser muy variados, desde artículos de prensa hasta informes científicos. Por ello, y debido a la complejidad y ambigüedad del lenguaje natural (aun cuando el dominio está perfectamente acotado) ésta no es una tarea sencilla.

De esta forma, la extracción de información ha sido estudiada en varios dominios muy restringidos involucrando a una gran comunidad de investigadores durante más de tres décadas. A pesar de ello, no es hasta hace poco más de 5 años que aparece el concepto *"legaltech"* o tecnología jurídica, que hace referencia al uso de la tecnología para ofrecer servicios jurídicos. Algunos de estos servicios abarcan revisar contratos para encontrar cláusulas inaceptables o requeridas (*LawGeex*); ayudar a detectar plazos, obligaciones o vigencias en los procesos de *due diligence* (*Luminance*); o analizar jurisprudencias con el fin de extraer información relevante para planear una estrategia procesal (*Ravel Law*).

En este trabajo se planea crear un sistema software basado en este mismo concepto. Se pretende que este sistema sea capaz de extraer la información relevante de una licencia escrita en lenguaje natural. Para ello, debe utilizar técnicas basadas en NLP centrándose, sobre todo, en el tipo de eventos (o acciones) que están permitidas, prohibidas y/o son requeridas. A partir de estos datos debe crear un RDF válido que los contenga junto con el nombre, la versión y el texto o código legal de la licencia. Algunos ejemplos del tipo de eventos que debe detectar y extraer son, entre otros, si se permite su uso comercial, copia, modificación o distribución; o si el usuario debe proporcionar el código fuente o acreditar al creador o los creadores de la misma.

ABSTRACT

Information Extraction is one of the main areas of focus inside Artificial Intelligence. This task focuses on deriving structured information from an unstructured or semi-structured document using *Natural Language Processing* (NLP) techniques. These documents can be very varied from press articles to scientific reports. Hence, this is not a simple task (even though the domain is perfectly limited) due to the complexity and ambiguity of natural language.

Therefore, Information Extraction has been studied in several very restricted domains involving a large community of researchers for more than three decades. In spite of this, it is not until just over 5 years ago that people started to talk about the *"legaltech"* or legal technology concept. This concept refers to the use of technology and softwares to offer legal services. Some of these services include review contracts to find unacceptable or required clauses (*LawGeex*); help detect deadlines, obligations or validity in *due diligence* processes (*Luminance*); or analyze jurisprudence in order to extract relevant information to raise a procedural strategy (*Ravel Law*).

In this work, we propose to create a software system based on this concept. The intention is to this system is able to extract the relevant information from a license written in natural language. Thus, it must uses techniques based on NLP and, above all, it must uses techniques in order to extract the type of events (or actions) that are allowed, required and/or forbidden. From this data it must creates a valid RDF that contains them along with the name, version and text or legal code of the license. Consequently, the type of events that should be detected are, among others, if their commercial use, copy, distribution or modification is allowed or not. Other possible events should be detected could be if the user must provide the source code or credit the creator/s of the license.

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1. INTRODUCCIÓN

La Extracción de Información (IE de aquí en adelante) [1, 2] ha sido históricamente uno de los retos principales de la Inteligencia Artificial. Esta tarea está íntimamente relacionada con el Procesamiento del Lenguaje Natural (NLP de aquí en adelante), la Lingüística Computacional y la Minería de textos. La IE busca localizar cierta información en texto libre – o no estructurado – en un dominio determinado produciendo información estructurada como una tabla relacional o un archivo XML, ignorando para ello otra información irrelevante (Ver 1). De manera más específica y coloquial se puede decir que su objetivo principal es conocer *quién hizo qué a quién, dónde, cómo y cuándo*. Esto, aun cuando el dominio está perfectamente acotado, no es una tarea simple debido a la complejidad y ambigüedad del lenguaje natural.

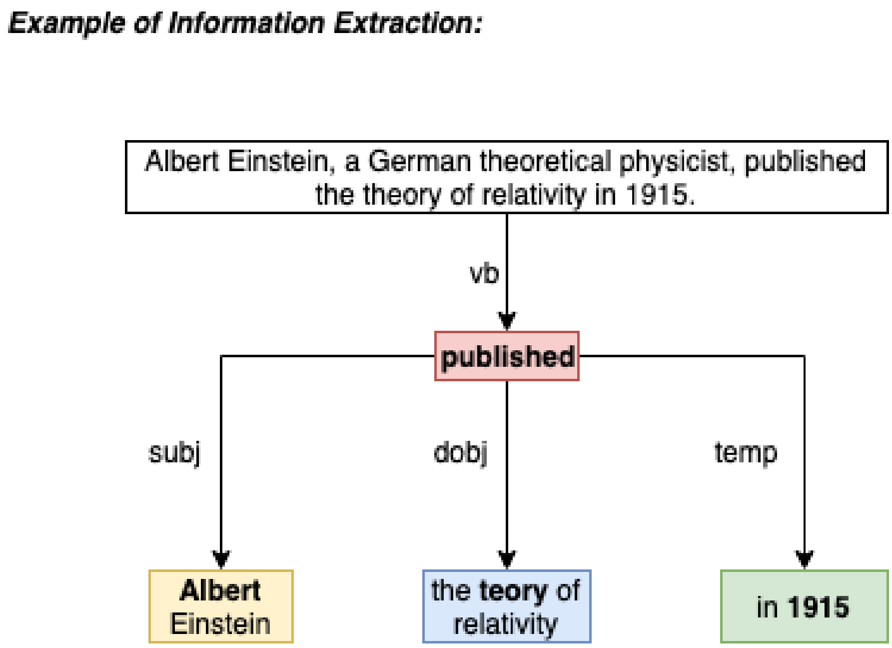

Fig. 1: Ejemplo básico de la Extracción de Información.

Es importante recalcar que la IE no busca comprender en su totalidad un texto, desentrañando todas las posibles interpretaciones y relaciones gramaticales. Algo que, por otro lado, es una tarea imposible a día de hoy desde un punto de vista tecnológico.

A menudo esta tarea es confundida con la **Recuperación de Información** [3], que consiste en encontrar material (generalmente documentos) de naturaleza no estructurada que satisfaga una necesidad de información dentro de grandes colecciones almacenadas en computadoras. Dicho de otra forma, consiste en encontrar un subconjunto de documentos, a partir de una colección más grande, que contengan información relevante dada una consulta específica basándose en una búsqueda por palabra clave o *keyword* que se podría ampliar mediante la utilización de tesauros [1] (Ver 2). La lista ordenada de documentos no proporciona ninguna información detallada sobre el contenido de los mismos ya que no se utiliza ningún conocimiento semántico. Por el contrario, el objetivo de la IE no es clasificar o seleccionar documentos, sino extraer de los mismos hechos sobre tipos predeterminados de eventos, entidades o relaciones, con el fin de construir representaciones más significativas, que se pueden utilizar para poblar bases de datos que proporcionen información estructurada, a fin de buscar patrones más complejos (resúmenes, tendencias, etc.) en *corpus* [2].

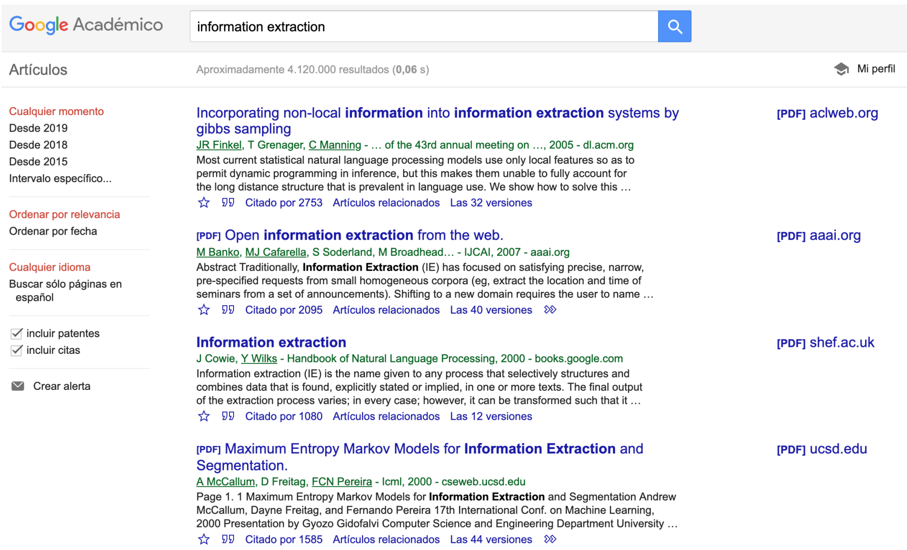

Fig. 2: Ejemplo básico de la Recuperación de Información. Búsqueda del término *"Information Extraction"* en la plataforma Google Scholar.

La información que se pretende conseguir mediante las técnicas de IE está previamente especificada en estructuras definidas por los usuarios, denominadas plantillas[3] u objetos, cada una de ellas con un número de espacios (o atributos), que son los que deben instanciarse o completarse por el sistema, conforme procese el texto.

[1] Un **tesauro** (o *thesaurus*, proveniente del latín) es una lista de palabras o términos que se interrelacionan entre sí a través de (1) relaciones jerárquicas (estructuras Todo/Parte), (2) relaciones de equivalencia (sinonimia, homonimia, antonimia y polisemia) y (3) relaciones asociativas (reducción polijerarquía). De una forma más específica, podemos decir que un tesauro es un intermediario entre el *lenguaje natural* (el usado en los documentos) y el *lenguaje controlado* (el empleado por los especialistas de un determinado campo del saber).

[2] Un **corpus** es un conjunto amplio y estructurado de ejemplos reales de uso de la lengua. Los más comunes son los textos, aunque también puede tratarse de muestras orales generalmente transcritas.

[3] Una **plantilla** o *template* es una estructura de tipo marco con slots que representan la información básica del evento. Esta información es del tipo participantes del evento, resultado obtenido, hora y ubicación, entre otras.

De esta forma, estas técnicas han estado en continuo estudio desde la década de los 80 gracias, en parte, a los concursos MUC (*Message Understanding Conference*) vigente desde 1987 hasta 1998 [4], ACE (*Automatic Content Extraction*) vigente desde 1999 hasta 2008 [5] y TAC (*Text Analysis Conference*) que está en activo desde 2009. Gracias a estas conferencias, las técnicas de IE han evolucionado considerablemente. Los primeros sistemas de IE se basaban en reglas codificadas manualmente. A medida que la codificación de las reglas se vuelve una tarea tediosa, nacen algoritmos para aprender estas reglas de manera automática a partir de ejemplos. Con el paso de los años se aprende que las reglas son demasiado *frágiles*, con lo que nace el aprendizaje estadístico o basado en datos. En este punto se implementan de manera paralela dos tipos de técnicas (*Hidden Markov Models* y *modelos condicionales basados en la máxima entropía*) que más tarde dan lugar a los modelos condicionales globales más conocidos como *Conditional Random Fields*.

Actualmente se utilizan ambas técnicas (tanto las basadas en reglas como las basadas en datos) dependiendo de la naturaleza de la tarea de extracción. También existen métodos híbridos que tratan de aprovechar los beneficios de ambos métodos.

Debido a su utilidad, la IE se aplica a múltiples áreas como:

- **Empresarial**: destacan el seguimiento de noticias como, por ejemplo, brotes de enfermedades y eventos terroristas; la atención al cliente, que origina problemas, por ejemplo, en cuanto a la vinculación de los correos eléctronicos de los clientes con una transacción específica; o la limpieza de datos, que trata de convertir las direcciones, por ejemplo, en su forma estructurada obteniendo el nombre de la carretera, el tipo de vía, la ciudad o el estado entre otros valores.

- **Personal**: los sistemas de gestión de información personal (PIM) buscan organizar los datos personales como documentos, correos electrónicos, proyectos y personas en un formato estructurado.

- **Investigación**: en los últimos años ha habido un gran auge en el campo de la bioinformática [6, 7, 8] debido al alcance de las extracciones de entidades nombradas de objetos biológicos como nombres de proteínas y genes. Esto es así gracias a que difieren en gran proporción a los nombres de personas o empresas también presentes en este tipo de documentos.

- **Orientadas a la Web**: algunos posibles ejemplos en este área podrían ser las bases de datos de citas como *Google Scholar*[4], de opiniones como *Seopatía by Steve*[5] o de la comunidad como *Rexa*[6]. En esta misma área, y con mayor fuerza cada vez se encuentran varios estudios de comparación de compras o colocación de anuncios en Internet. Finalmente, un gran problema para la IE

[4] `https://scholar.google.es/`
[5] `https://www.getrevue.co/profile/estevecastells/`
[6] `http://rexa.info.`

es permitir consultas de búsqueda que involucren entidades y sus relaciones en la *WWW*. Esta última tarea comenzó a aparecer en torno a 2006 [9, 10].

- **Legal**: algunas de las principales aplicaciones desarrolladas en este campo son *LawGeex* que revisa contratos para detectar cláusulas inaceptables o requeridas, *Luminance* que ayuda a detectar plazos, obligaciones o vigencias a tener en cuenta en los procesos de *due diligence* o *Ravel Law* que analiza juridisprudencias para extraer información relevante para plantear una estrategia procesal. Se puede observar una review completa de este tema en [11].

En este trabajo se trata de dar solución a este problema en el área legal empleando técnicas de NLP debido a que es un área en la que apenas se ha empezado a trabajar (las primeras nociones datan de 2015). Para ello se pretende expandir o construir un sistema que sea capaz de reconocer cualquier información relevante que contengan las licencias, comparándolas con su RDF correspondiente para obtener la fiabilidad de dicho sistema.

1.1. Motivación

La principal motivación de este trabajo es estudiar el software existente capaz de anotar cualquier tipo de *frame* e intentar expander alguno de ellos con el fin de ofrecer la posibilidad de trabajar con frames propios de eventos legales. En el caso de que la tarea de expansión resulte demasiado tediosa, se tratará de crear un sistema que sea capaz de procesar un texto legal, en este caso, cualquier licencia; y extraiga toda la información relevante que pueda contener como los permisos o restricciones. Esta tarea no es trivial ya que las licencias están escritas en lenguaje natural.

Esta segunda tarea supone estudiar licencias – permisos, restricciones y obligaciones que soporta –; así como la estructura básica que siguen para poder probar la funcionalidad del sistema.

1.2. Objetivos

El objetivo principal de este trabajo es conseguir expandir o crear un sistema que trabaje con textos legales. Para ello se proponen una serie de tareas a realizar:

1. **Estudio del Estado del Arte**: se estudian las tareas principales de la IE, se profundiza en los diferentes métodos que existen para la extracción de eventos (EE de aquí en adelante) y se estudian las diferentes técnicas existentes conocidas para los métodos de EE.

2. **Expasión o creación del sistema**: se propone la expansión de alguna de las técnicas estudiadas en la tarea anterior en el ámbito legal. En caso de que no sea posible, se propone la creación de una aplicación que sea capaz de extraer eventos legales.

3. **Selección de corpus**: se seleccionan los corpus de estudio y de prueba que utilizará el sistema para probar la fiabilidad.

4. **Experimentación del sistema con el corpus de entrenamiento**: se aplica el corpus de estudio para la obtención de reglas que conforman el sistema haciendo que la salida del mismo sea lo más exacta y rica posible.

5. **Experimentación del sistema con el corpus de prueba**: se aplica el corpus de prueba al sistema y se comprueba el rendimiento del mismo.

6. **Resultados**: se comentan los resultados obtenidos en la tarea anterior.

7. **Conclusiones y líneas futuras**: se plantean las conclusiones del trabajo, junto con posibles mejoras para trabajos futuros.

1.3. Estructura

El trabajo presentado en esta memoria se divide en las siguiente secciones principales:

- La **sección 2** contiene el Estado del Arte. Esta sección se divide en dos subsecciones principales. En la primera figuran las tareas principales de la IE. Mientras que en la segunda se hace referencia a los posibles enfoques para la EE destacando las técnicas existentes conocidas.

- La **sección 3** contiene el planteamiento del problema donde se tratan una a una las dificultades encontradas, proponiendo para cada una de ellas una posible solución.

- La **sección 4** contiene el experimento realizado y se divide en varias subsecciones: corpus de estudio, implementación, código, corpus de prueba, evaluación y resultados obtenidos.

- Finalmente, la **sección 5** contiene las conclusiones del trabajo, así como posibles mejoras a tener en cuenta para cualquier desarrollo o profundización futura del mismo.

2. Estado del Arte

En esta sección se presenta el estado del arte – desde un punto teórico – de las diferentes tareas de la IE, los métodos posibles para la EE y las diferentes herramientas software existentes para la EE en el ámbito legal.

2.1. Principales tareas de la IE

La IE se compone de cuatro tareas principales: reconocimiento de entidades nombradas (NER), reconocimiento de correferencia (CR), extracción de relaciones (RE) y extracción de eventos (EE). A continuación se describen con detalle cada una de ellas aportando uno o más ejemplos para su total comprensión.

2.1.1. Reconocimiento de entidades nombradas – NER –

Esta tarea aborda el problema de la identificación (detección) y clasificación de tipos predefinidos de **entidades nombradas** tales como organizaciones, personas, nombres de lugares, expresiones temporales, expresiones numéricas y de divisas, etc. La tarea de NER puede, además, incluir la extracción de información descriptiva a partir un texto en relación a las entidades detectadas, rellenando plantillas simples. Por ejemplo, en el caso de las personas puede incluir extraer el puesto de trabajo, la nacionalidad, el género y otras características de la misma. Se ha de destacar que el reconocimiento de entidades nombradas también implica el proceso de **lematización** de dichas entidades, que es clave en lenguas flexivas.

La **lematización** es un proceso lingüístico que consiste en, dada una forma flexionada, es decir, en plural, en femenino, conjugada, etc., hallar el **lema** correspondiente, siendo éste la forma que por convenio se acepta como representante de todas las formas flexionadas de una misma palabra. Por ejemplo el lema de la palabra *perras* es *perro*, mientras que el lema de la expresión *he ido a correr* es *correr*.

2.1.2. Reconocimiento de correferencia – CR –

Esta tarea aborda la identificación de diferentes menciones de la misma entidad en el texto. Las menciones de las entidades pueden ser de varios tipos [1]. Ésta no es una tarea trivial ya que, por un lado, presta un elemento de estilo y cohesión al escritor humano, mientras que por otro, agrega otra dimensión de oscuridad a la comprensión mecánica del lenguaje. Por ello se podría decir, en cierto sentido, que es el *hipervínculo del lenguaje natural.* [12]

En muchas ocasiones se ha confundido con la **Resolución de la Anáfora** de manera errónea ya que la correferencia es una relación de equivalencia, mientras que la anáfora no es ni reflexiva, ni simétrica (ni transitiva). A modo de ejemplo, se puede decir que dos frases nominales se relacionan entre sí mediante correferencia si ambas se resuelven en un único referente (sin ambigüedad). Sin embargo, se dice

Tipo	Descripción	Ejemplo
Nombradas	Referidas por su nombre	*Barack Obama visitará la India en enero de 2015. Mr Obama se reunirá con los principales líderes del partido del Congreso de oposición*
Pronominales	Referidas por su pronombre	*Barack Obama visitará la India en enero de 2015. Él se reunirá con los principales líderes del partido del Congreso de oposición*
Nominales	Referidas por un sintagma nominal	*Barack Obama visitará la India en enero de 2015. El Presidente de los EEUU se reunirá con los principales líderes del partido del Congreso de oposición*
Implícitas	No existe la anáfora	*Barack Obama visitará la India en enero de 2015. Se reunirá con los principales líderes del partido del Congreso de oposición*

Tab. 1: Tipos de entidades posibles dentro de la tarea CR

que una frase nominal A es el antecedente anafórico de una frase nominal B si y solo si A es necesaria para la interpretación de B.

2.1.3. Extracción de relaciones – RE –

Esta tarea aborda la detección y clasificación de relaciones predefinidas entre dos o más entidades nombradas (NE) en un texto [13]. Los tipos de relaciones son ilimitados y están predefinidos y fijados como parte de la especificación de la tarea. Algunos ejemplos podrían ser *employed_at(Aida, Crisser) donde se interpreta que Aida es una empleada de Crisser; o founded_by(Apple, Steve Jobs)* donde se interpreta que Apple fue fundada por Steve Jobs.

Esta tarea se enfrenta a muchos desafíos debido a que hay una gran variedad de relaciones posibles que varían de un dominio a otro, las relaciones no tienen por qué ser binarias, las técnicas de aprendizaje automático supervisadas se enfrentan a una mayor dificultad (normalmente no se dispone de suficientes datos de entrenamiento) y la ambigüedad inherente juega un gran papel en cuanto a lo que una relación "*significa*"(a menudo se refleja en los altos desacuerdos entre anotadores). Finalmente, y dado que la expresión de una relación depende en gran medida del lenguaje, hace que esta tarea sea dependiente del lenguaje.

2.1.4. Extracción de eventos – EE –

Esta tarea aborda la identificación de eventos en texto libre y la derivación de información estructurada sobre los mismos, buscando identificar *quién hizo qué a quién, cuándo, dónde, a través de qué métodos y por qué*. La labor de EE implica la extracción de varias entidades y relaciones entre ellas [14].

Un ejemplo podría ser una *adquisición*. Si se considera la representación <**Company**> <**Buy**><**Company**>, las palabras identificadas en el texto que se refieren a *empresas* están vinculadas al concepto <**Company**>, y (las conjugaciones de) los *verbos* que tienen el *significado* de *adquisición* están asociados a <**Buy**>. Las representaciones de este evento se pueden extraer de los encabezados de noticias como *"Google adquiere Picnik"*, *"Lala comprada por Apple"* o *"Skype vendido a Microsoft"*.

2.2. Métodos existentes para la EE

Para poder realizar la tarea de EE existen tres enfoques o tipos de métodos diferentes [14]: basados en el conocimiento (reglas), basados en la estadística (datos) e híbridos. A continuación se describen cada uno de ellos.

2.2.1. Métodos basados en el conocimiento

Este tipo de métodos extraen el conocimiento a través de la representación y la explotación del conocimiento experto, generalmente mediante enfoques basados en patrones. Estos patrones expresan reglas basadas intrínsecamente en el conocimiento lingüístico y lexicográfico; así como en el conocimiento humano existente con respecto al contenido del texto que se va a procesar. Esto alivia los problemas de los métodos basados en datos con respecto al significado del texto.

La información se extrae de los corpus mediante el uso de patrones lingüísticos predefinidos o descubiertos, que pueden ser tanto patrones *léxico-sintácticos* – que combinan representaciones léxicas e información sintáctica con expresiones regulares – como patrones *léxico-semánticos* – que hacen uso de información semántica –. La información semántica se suele agregar mediante *gazetteers*, que utilizan el significado lingüístico del texto, o mediante *ontologías*. Además, es posible definir expresiones potentes utilizando elementos léxicos, sintácticos y semánticos, y los resultados son fácilmente interpretables y rastreables. Los patrones son útiles cuando se necesita extraer información muy específica.

Sin embargo, la principal desventaja es que para poder definir patrones que recuperen la información correcta y deseada, se requieren conocimientos léxicos y posiblemente también conocimientos previos de dominio. Otras posibles desventajas se relacionan con la definición y el mantenimiento de patrones, ya que la adquisición de conocimientos se hace más difícil (por ejemplo, en costos y consistencia) cuando los patrones deben ampliarse para cubrir más situaciones debido al hecho de que los patrones son, por lo general, hechos a mano.

2.2.2. Métodos basados en datos

Este tipo de métodos tienen como objetivo convertir los datos en conocimiento mediante el uso de estadísticas, aprendizaje automático, álgebra lineal, etc. Los inconvenientes principales de estos métodos son que no tratan el significado explícitamente, es decir, descubren relaciones en cuerpos sin considerar la semántica; y que requieren una gran cantidad de datos para obtener resultados estadísticamente significativos dado que necesitan un entrenamiento previo. Por otro lado, la principal ventaja es que al no basarse en el conocimiento, no se requieren recursos lingüísticos ni conocimiento experto, es decir, no requieren conocimientos previos de un dominio específico.

2.2.3. Métodos híbridos

Este tipo de métodos combinan el conocimiento y los métodos basados en datos. Como ambos enfoques tienen sus desventajas, la combinación de los dos métodos podría dar los mejores resultados. En general, un enfoque puede ser visto principalmente como datos o impulsado por el conocimiento. Sin embargo, hay un número cada vez mayor de investigadores que combinan ambos enfoques por igual, y que de hecho emplean enfoques híbridos.

2.3. Técnicas basadas en el conocimiento

2.3.1. FrameNet

FrameNet [2] es un recurso electrónico basado en **marcos semánticos** (o semántica de marcos) creado principalmente por *Charles J. Fillmore* en la Universidad de Berkeley y lanzado en torno al año 1998. Esta semántica está incluida dentro de la **lingüística cognitiva** [15], ya que no solamente considera los *aspectos formales*, si no que también da cuenta del *lenguaje como facultad inherente* al individuo y, como tal, debe aludir a los aspectos neurolingüísticos, psicolingüísticos, sociolingüísticos y antropolingüísticos que hacen posible el funcionamiento del lenguaje como una herramienta de cognición, representación, comunicación e interacción entre los individuos. Esto quiere decir que la lingüística cognitiva no es una sola teoría del lenguaje, si no un marco flexible que enfatiza en el hecho de que definir una categoría puede implicar describir algunos de sus miembros principales en lugar de dar simplemente una definición abstracta. También subraya que la definición abstracta no tiene que constituir en un conjunto único de características definitorias que pertenezcan única y distintivamente a esa categoría. En resumen, se puede concluir que la **lingüística cognitiva** es "*el estudio del lenguaje natural tratado como un fenómeno mental*".

En cuanto a los **marcos semánticos**, la teoría afirma que las personas entienden el significado de las palabras en gran parte en virtud de los marcos que evocan. Los **marcos** representan fragmentos de historias, que sirven para conectar un grupo de palabras a un conjunto de significados. Es por ello que el estudio de los marcos semánticos intenta definir los marcos y los "participantes/elementos" (FEs) involucrados en cada uno de ellos (ver ejemplos 2 y 3). La lista completa de *frames* está disponible en `https://framenet.icsi.berkeley.edu/fndrupal/frameIndex`.

Marco	Descripción	Ejemplo
Activity_finish	An Agent finishes an Activity, which can no longer logically continue. This frame is a subframe of Activity.	Jason COMPLETED grading the papers late Sunday night.
Activity_pause	An Agent pauses in the course of an Activity.	The government FROZE settlement construction to facilitate peace talks.
Arrest	Authorities charge a Suspect, who is under suspicion of having committed a crime (the Charges), and take him/her into custody.	The police ARRESTED Harry on charges of manslaughter.
Legal_rulings	An Authority with the power make decisions hands down a Finding over a question presented in a formal or informal Case.	In the California case, a judge RULED Oct. 12 that Tendler must pay the bloggers' legal fees.
Legality	Words in this frame describe the status of an Action with respect to a Code of laws or rules. An Object may also be in violation or compliance of the Code by virtue of its existence, location or possession.	Scores of ILLEGAL immigrants cross the border every year. Feeding the buffalo is PROHIBITED according to Code 138.

Tab. 2: Ejemplos de marcos semánticos disponibles en FrameNet

Por supuesto, el proceso de entender una oración en inglés (o en cualquier otro idioma) no solo depende de conocer las palabras y los marcos que evocan, sino también de las construcciones gramaticales que determinan la jerarquía sintáctica de la oración y, a su vez, el orden de las palabras (este concepto se basa en la ***teoría de la gramática de la construcción***, en la que las construcciones no solo definen las relaciones entre los elementos que evocan el marco y los elementos de llenado de roles, sino que también, en muchos casos, tienen un significado propio). El trabajo en el proyecto **FrameNet** supone la existencia de dicha teoría.

El principal producto de este trabajo (la **base de datos léxica FrameNet**) contiene actualmente más de 13.000 *unidades léxicas* (ver 4), aproximadamente 7.000

Marco	FEs	Descripción
Activity_finish	Activity[Act]	Activity that the Agent has finished.
	Agent[Agent]	Agent who has finished an Activity.
	Manner[Manr]	Manner an Agent is engaged in finishing an Activity.
	Place[Place]	Place where the Agent finishes the Activity.
	Purpose[Purp]	Purpose for which an Agent finishes for an Activity.
	Time[Time]	Time when the Activity finishes.
Activity_pause	Activity[Act]	Activity for which an Agent is pausing.
	Agent[Agent]	An Agent pauses in the course of an Activity.
	Completeness [Cmp]	The extent to which the Agent pauses in the Activity.
	Manner[Manr]	Manner in which an Agent pauses during the course of an Activity.
	Place[Place]	Place where an Agent pauses in the course of an Activity.
	Purpose[Purp]	Purpose for which an Agent pauses in the course of an Activity.
	Time[Time]	Time at which an Agent pauses in the course of an Activity.
Arrest	Authorities [Auth]	The Authorities charge the Suspect with commiting a crime, and take him/her into custody.
	Charges [Chrg]	Charges identifies a category within the legal system; it is the crime with which the Suspect is charged.
	Offense [Off]	Offense identifies the ordinary language use of the reason for which a Suspect is arrested.
	Suspect [Susp]	The Suspect is taken into custody, under suspicion of having committed a crime.
Legal_rulings	Authority [Auth]	The Authority (which may be the jury, judge, magistrate or court) decides on the Finding.
	Case [Case]	Question on which the Authority gives a Finding.
	Defendant [D]	The person about whom the Authority passes a judgment or Finding.
	Finding [Fin]	Outcome of the Authority's deliberation or consideration.
Legality	Action[Act]	The Action is the behavior which complies with or violates the Code.
	Object[Obj]	The Object complies with or violates the Code by virtue of its existence, location or possession.
	Code[Cod]	The Code is the set of rules, laws or regulations that determine whether the Action is allowed or prohibited.
	Explanation[ ]	The Explanation denotes a proposition from which the main clause (headed by the target) logically follows.

Tab. 3: Ejemplos de FEs asociados a marcos semánticos

de las cuales están completamente anotadas; en más de 1.000 marcos semánticos relacionados jerárquicamente, ejemplificados en más de 200.000 frases anotadas.

Una **unidad léxica (LU)** es un emparejamiento de una palabra con un significado. Típicamente, cada sentido de una palabra polisémica pertenece a un marco semántico diferente, una estructura conceptual similar a un "*script*"que describe un tipo particular de situación, objeto o evento junto con sus participantes y objetos.

El objetivo del proyecto **FrameNet** era definir los **marcos semánticos**, creando una descripción de cada marco en su conjunto y de cada uno de sus elementos. Dichos marcos consisten en agrupaciones de ideas evocadas por palabras o grupos de palabras que tienen cierta superposición semántica, y dividirlos en grupos para, más tarde, combinarlos en grupos lo suficientemente grandes como para hacer marcos razonables en los que se puede - equivalentemente - llamar a las palabras objetivo, las unidades léxicas o los elementos que evocan marcos. Al final, se quiere terminar con grupos de palabras de destino en cada marco que tengan un tipo particular de superposición semántica. En el pasado, los criterios para tal agrupación han sido *informales* e *intuitivos*, pero ahora estos criterios son más explícitos. En un sentido práctico, los criterios son de dos tipos:

- Una lista de verificación de características, donde si un criterio de similitud no se cumple, se deberían poner las palabras en diferentes marcos. Los criterios a seguir son los siguientes:
    - Las palabras deben tener el mismo número y tipo de elementos de marco tanto implícitos como explícitos.
    - Las palabras deben denotar la misma parte de la escena.
    - Las palabras deben precisar las mismas relaciones.
- Un principio más difícil de definir para que las agrupaciones sean útiles – especialmente como paráfrasis y como respuestas alternativas a una pregunta – es destacar los criterios no utilizados para la división de marcos. Los criterios a destacar son:
    - Las diferencias gramaticales tales como la formación de la pasiva, la composición de elementos de marco extra-temáticos, las construcciones de tiempo/aspecto y las diferencias POS.
    - Los antónimos.
    - Las diferencias de uso tales como deixis, registro, dialecto y evaluación.

Las principales aplicaciones del proyecto **FrameNet** son, entre otras, el reconocimiento de vinculaciones textuales, el parafraseo, el sistema de pregunta-respuesta (ambos resaltados con anterioridad) y la extracción de información, como es el caso en el que se centra este trabajo.

Marco	LUs	Estado
Activity_finish	complete.v	Finished_Initial
	completion.v	Created
	conclude.v	Finished_Initial
	finish.v	Finished_Initial
	graduate.v	Created
	tie up.v	Needs_SCs
	wrap up.v	Created
Activity_pause	adjourn.v	Created
	freeze.n	Finished_Initial
	freeze.v	Finished_Initial
	moratorium.n	Finished_Initial
	pause.n	Created
	suspend.v	Finished_Initial
	take break.v	Created
Arrest	apprehend.v	Finished_Initial
	apprehension.n	Finished_Initial
	arrest.n	Finished_Initial
	arrest.v	Finished_Initial
	book.v	Finished_Initial
	bust.n	Needs_SCs
	bust.v	Finished_Initial
	collar.v	Finished_Initial
	cop.v	Insufficient_Attestations
	nab.v	Finished_Initial
	summons.v	Needs_SCs
Legal_rulings	adjudicate.v	New
	decree.v	Finished_Initial
	deem.v	Created
	judge.v	Finished_Initial
	judgment.v	Created
	rule.v	Finished_Initial
Legality	criminal.a	Created
	fair.a	Created
	illegal.a	Finished_Initial
	illicit.a	Finished_Initial
	lawful.a	Finished_Initial
	legal.a	Finished_Initial
	legitimate.a	Created
	licit.a	Created
	permissible.a	Created
	prohibited.a	Created
	unlawful.a	Finished_Initial
	wrong.a	Created
	wrongful.a	Created
	wrongly.adv	Created

Tab. 4: Conjunto de LUs asociadas a un marco semántico específico

Esta extracción se puede hacer tanto de forma **directa** como por medios de un **ASRL**. Debido a que la etiquetación de forma directa a través de anotaciones FrameNet es muy costosa y lenta, en [16] se desarrolla la etiquetación por medios ASRL que produce de forma automática, utilizando técnicas de aprendizaje automático, anotaciones muy similares a las de FrameNet en textos nuevos nunca antes vistos.

Las tareas principales de un sistema ASRL (o SRL simplemente) son encontrar los constituyentes de las frases relevantes y darles a cada uno de ellos la etiqueta semántica correcta. El primer sistema ASRL consistía en etiquetar los constituyentes (ya sea con roles semánticos abstractos o con específicos del dominio) dada una oración de entrada y un marco de destino. Este nuevo sistema se basa en clasificadores estadísticos entrenados en aproximadamente 50.000 oraciones anotadas a mano y recuperadas del proyecto **FrameNet**. Cada una de estas oraciones se analizó en un árbol sintáctico del que se extraían varias características léxicas y sintácticas, incluyendo el tipo de frase de cada constituyente, su función gramatical y su posición en la oración. Estas características están derivadas del corpus de **Penn TreeBank** [7].

2.3.2. SEMAFOR

En [17] nace un nuevo sistema que identifica argumentos de marco semántico utilizando un modelo lineal con características diseñadas a mano basadas en un análisis de dependencia. Este sistema modela instancias nulas incluyendo referencias a argumentos no locales. Sustituye los modelos de [18] por dos modelos *log-lineales* (con un solo conjunto de ponderaciones en cada uno de ellos) para encontrar un análisis semántico de marco completo. En [19] se producen pequeñas variaciones tales como la eliminación de los intervalos de argumentos utilizando heurísticas sintácticas y *beam search* (o AD3) para decodificar respetando las restricciones; y en [20] se extiende de nuevo el modelo mediante el uso de anotaciones ejemplares de FrameNet, características de la guía PropBank y la jerarquía FrameNet. Finalmente cabe destacar que este proyecto está escrito en Java y es de libre acceso [8].

2.3.3. Framat

En [21] se desarrolla un nuevo sistema que agrega características basadas en el contexto de la oración y el discurso para mejorar un sistema SRL adaptado para los marcos semánticos utilizando un modelo global con ranking. Para ello se definen las siguientes características:

- **A nivel del discurso**: utilizan directamente el conocimiento del discurso en forma de cadenas de referencias, estas se generalizan mejor que las características léxicas y semánticas tradicionales.

[7] **Penn TreeBank** es un corpus lingüístico donde cada frase ha sido parseada - o anotada - con su estructura sintáctica, representada generalmente como una estructura arbórea, empleando en la mayoría de los casos un etiquetado gramatical. El conjunto de etiquetas POS está disponible en A

[8] `https://github.com/Noahs-ARK/semafor-semantic-parser`

- **A nivel de oraciones**: modelan las propiedades de una estructura de marco como un todo. Las características contextuales proporcionan información adicional necesaria para comprender y asignar roles a este nivel.

- **Léxicas**: se pueden calcular utilizando métodos de semántica distributiva y una adaptación para modelar el significado de las palabras específicas del documento.

En [22] se extiende este modelo mediante incorporaciones de aprendizaje para los caminos de dependencia entre el predicado y sus argumentos. Para ello crean un nuevo modelo conocido como *PathLSTM* basado en mate-tools que modela relaciones semánticas entre un predicado y sus argumentos mediante el análisis de la ruta de dependencia aplicando una LSTM (un tipo específico de NN). Este modelo considera las rutas lexicalizadas, que se descomponen en secuencias de elementos individuales, es decir, las palabras y las relaciones de dependencia en una ruta. Luego se aplican redes de memoria a corto y largo plazo para encontrar una función de composición recurrente que pueda reconstruir una representación apropiada de la ruta completa a partir de sus partes individuales. Al modelar las rutas de dependencia como secuencias de palabras y dependencias, se aborda de manera implícita el problema de la dispersión de datos. Finalmente cabe destacar que este proyecto está escrito en Java y es de libre acceso[9].

2.3.4. OPEN-SESAME

En [23] se desarrolla el que es considerado como el primer analizador semántico libre de sintaxis gracias a su modelo *softmax-margin SegRNN*. Este modelo es una modificación de los modelos *SegRNN*[10] que fomentan la recuperación por encima de la precisión abandonando el filtrado sintáctico y las características sintácticas para la identificación de argumentos de marcos semánticos. Finalmente, a este modelo se le añade información semántica usando (1) un enfoque segmentado que incorpora características de dependencia automática o analizadores de estructura de frase, y (2) un enfoque de andamio sintáctico, descartando de esta forma la necesidad de un analizador sintáctico ya que conserva el beneficio de las características sintácticas sin costo computacional mediante la identificación de los constituyentes sin etiqueta entrenándolo mediante el corpus lingüístico **Penn Treebank**. Finalmente cabe destacar que este proyecto está escrito en Python y es de libre acceso[11].

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[9] `https://github.com/microth/mateplus`

[10] Las **SegRNN (o SRNN)** combinan dos potentes herramientas de aprendizaje automático (1) el aprendizaje de representación y (2) la predicción estructurada. Además, son una variante de los campos aleatorios condicionales semi-Markov ya que definen una distribución de probabilidad condicional sobre el espacio de salida (segmentación y etiquetado) dada la secuencia de entrada [24].

[11] `https://github.com/swabhs/open-sesame`

2.4. Técnicas existentes basadas en la estadística

2.4.1. PropBank

PropBank [25] es un enfoque práctico de la representación semántica en el que se agrega una capa de información del tipo *predicado-argumento*, o etiquetas[12] de roles semánticos a las estructuras sintácticas de **Penn TreeBank**. Esta anotación sintáctica identifica tanto los sujetos como los objetos del verbo, proporcionando etiquetas con las funciones semánticas del tipo *temporal/locativo* sin ser capaz de distinguir los roles desempeñados por el sujeto u objeto gramatical de un verbo. Por lo que se podría decir que está *orientado al verbo* y que no anota eventos o estados de cosas descritas usando sustantivos (ver 3).

Frameset **decline.01** "go down incrementally"

Arg1: entity going down

Arg2: amount gone down by, EXT

Arg3: start point

Arg4: end point

Ex: . . . [$_{\text{Arg1}}$ its net income] *declining* [$_{\text{Arg2-EXT}}$ 42%] [$_{\text{Arg4}}$ to $121 million] [$_{\text{ArgM-TMP}}$ in the first 9 months of 1989]. (wsj_0067)

Frameset **decline.02** "demure, reject"

Arg0: agent

Arg1: rejected thing

Ex: [$_{\text{Arg0}}$ A spokesman$_i$] *declined* [$_{\text{Arg1}}$ *trace*$_i$ to elaborate] (wsj_0038)

Fig. 3: Ejemplo de los dos marcos posibles del verbo *"decline"*

Además, estas anotaciones producidas por **PropBank** son a *nivel sintáctico*, ya que tan solo anotan el sentido literal del objetivo, prefiriendo metas pequeñas, incrementales y fáciles de alcanzar. Este proceso de anotación(ver 4) se realiza a partir de un etiquetador automático basado en reglas y corregido a continuación de manera manual. Debido a esto, una ventaja considerable con respecto a **FrameNet** es que necesita una menor comprensión del contexto en el que se encuentra, lo que hace que resulte una tarea menos compleja. Aunque, por contra, los resultados obtenidos contienen menos información.

En cuanto a la creación del conjunto de marcos en **PropBank**, a diferencia de **FrameNet** (que no considera las diferencias sintácticas), éste necesita que coinci-

[12] En principio hay un total de 12 etiquetas diferentes disponibles para cada uno de los constituyentes (DIR, LOC, MNR, TMP, EXT, REC, PRD, PRP, DIS, ADV, MOD y NEG).

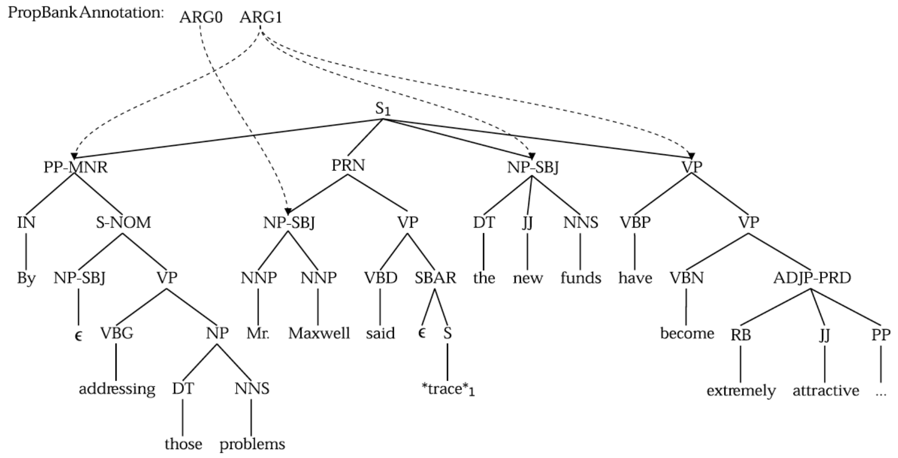

Fig. 4: Ejemplo de la anotación PropBank

dan tanto el número de posibles roles semánticos como los significados de los usos para agruparlos en un mismo conjunto. Además, **PropBank** no diferencia entre las *oraciones causativas*[13] e *incoativas*[14].

Finalmente, en cuanto a la metodología usada, se puede destacar que PropBank emplea *backoff* basada en una red que combina las características del modelo. Esta solución restringe el tamaño de los conjuntos de características ya que resulta difícil añadir nuevas características al problema. Las características estándar del problema son: predicado, camino mínimo desde el predicado hasta el constituyente a ser clasificado, tipo de frase (NP, PP, etc.), posición (antes/después del predicado), voz (activa/pasiva), palabra clave y sub-categorización.

Las tareas principales que desempeña **PropBank** en principio son identificar los diferentes argumentos o constituyentes de cada predicado y asignar un rol a cada uno de ellos. En [26] se realiza un estudio en el que se indica la utilidad de cada una de las características anteriores con respecto a cada una de las dos tareas mencionadas. En cuanto a la tarea de identificar, los argumentos las características destacadas son el uso del camino y la palabra clave (junto con su etiqueta POS). Además, del uso del tipo de frase junto con el predicado; y si este último está especificado, la distancia también podría ser útil. En cuanto a la tarea de asignar un rol a cada argumento, se destaca el uso del tipo de frase y la palabra clave (sobre todo si se conoce el predicado). Por otra parte, tanto el uso del camino, como el de la sub-categorización y la voz (estos dos últimos debido a que son compartidos por toda la oración, es decir, no son discriminantes en ningún aspecto) no tienen ningún interés.

[13] Las **oraciones causativas** son aquellas en las que el sujeto de la oración no realiza la acción, sino que provoca que otro lo haga. Por ejemplo: *"El árbitro hizo repetir el lanzamiento."*

[14] Las **oraciones incoativas** son aquellas en las que hay una acción progresiva o se indica el comienzo de una acción o cosa. Por ejemplo: *"Ha comenzado a llover."* o *"Las niñas se echaron a reír."*

2.4.2. Sistemas derivados de PropBank

- En [27] se describe un sistema de IE independiente del dominio con identificación automática de estructuras del tipo *predicado-argumento*, igual que en PropBank. En este sistema se aplican dos métodos diferentes. El primero de ellos es el estadístico usado en PropBank, cuya tarea es identificar los componentes del árbol de análisis correspondientes a los argumentos de cada predicado codificado en PropBank. El segundo método es nuevo y está basado en el aprendizaje inductivo, cuya tarea es reconocer el rol correspondiente de cada argumento. La ventaja principal del aprendizaje inductivo a través de árboles de decisión es que les permite probar fácilmente grandes conjuntos de características y estudiar el impacto de cada característica en el analizador aumentado que genera estructuras de argumentos de predicado. Por ello, utilizan el algoritmo de aprendizaje del árbol de decisión inductivo C5 [28], para implementar tanto el clasificador que identifica los constituyentes de los argumentos como el clasificador que etiqueta los argumentos con sus roles. Para ello añaden dos características principales: reducen a 7 etiquetas principales (a saber, PERSON, ORGANIZATION, LOCATION, PERCENT, MONEY, TIME y DATE) los constituyentes y añaden a la palabra principal su respectivo POS. Este nuevo método obtiene resultados más precisos que PropBank para predicados *no conocidos*.

- En [18] se reemplaza el algoritmo de clasificación estadística por uno que usa SVM[15] y luego se agrega al conjunto de características existente. Este nuevo sistema añade, además de las características mencionadas en [27], algunas características nuevas: agrupación de verbos (en un total de 64 clases usando el modelo de co-ocurrencia probabilística de Hofmann & Puzicha [29]), ruta parcial, información del sentido verbal, palabra principal de las frases preposicionales (por ejemplo, etiquetar *PP-in* en lugar de *PP*), tener en cuenta la primera y la última palabra de un constituyente junto con su POS correspondiente, concatenación del tipo de constituyente y su posición ordinal del predicado, definir la distancia del árbol constituyente y añadir tanto las características relativas de los constituyentes así como las palabras de referencia temporales. En cuanto a la identificación del argumento, obviamente obtiene peores resultados que si se obtuvieran a mano, pero en cuanto a la clasificación de dichos argumentos funciona significativamente mejor. Al intentar hacer ambas tareas el SVM hace un buen trabajo en ambas etapas.

- En [26] proponen un nuevo conjunto de características (ver 5) con el fin de explotar mejor la información que proporciona el árbol analizador (ver ejemplo 5).

[15] Las **SVM** son un conjunto de algoritmos de aprendizaje supervisado desarrollados por Vladimir Vapnik y su equipo en los laboratorios ATT. Estos métodos están propiamente relacionados con problemas de *clasificación* y *regresión*. Dado un conjunto de ejemplos de entrenamiento (de muestras) podemos etiquetar las clases y entrenar una SVM para construir un modelo que prediga la clase de una nueva muestra.

Característica	**Ejemplo**	
Descripción	Palabra	Marco
Añadir marcos semánticos que varían en función de la clasificación del constituyente	*states*	np_v_NP_np, np_v_CUR_np (sin identificar la cat. sintáctica), np_give_CUR_np con el predicado lematizado
Añadir el lema del predicado al tipo de constituyente	*states*	give_NP
Combinar la palabra clave con el lema del predicado	*states*	give_states
Combinar la voz y la posición del verbo con respecto al constituyente	*states*	passive_before
Si el constituyente es un PP, entonces se obvia	—	—

Tab. 5: Características propuestas en [26]

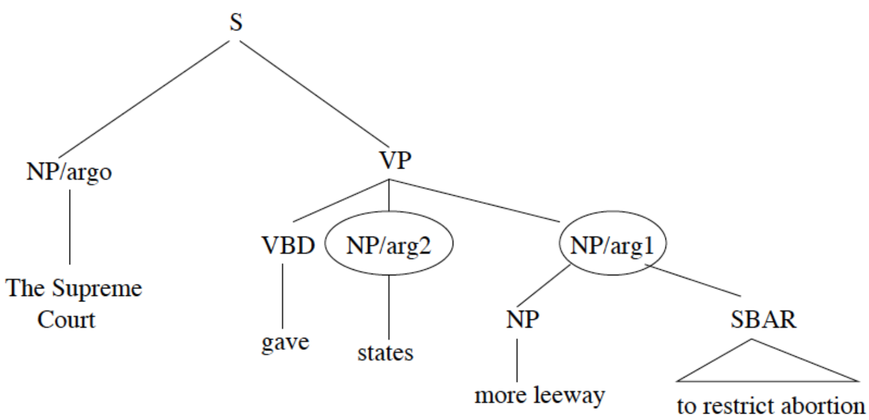

Fig. 5: Oración de ejemplo obtenida de [26] donde se pueden apreciar varios NPs (predicados nominales) como pivotes del VP (predicado verbal).

2.4.3. AllenNLP

En [30] se lanza una nueva plataforma web de acceso libre[16] basada en la idea de PropBank pero sustituyendo el modelo propuesto por uno basado en *BiLSTM (Bidirectional Long Short-Term Memory)*, que es un tipo especial de RNN. AllenNLP se centra en varias tareas entre las que destacan el SRL(6, 7, 8, 9) y el analizador de constituyentes(10) que divide un texto en constituyentes. Los no terminales en el árbol son tipos de frases y los terminales son las palabras en la oración. Este modelo utiliza incrustaciones ELMo [31], que están completamente basadas en caracteres y mejora el rendimiento obtenido con Penn TreeBank hasta el momento.

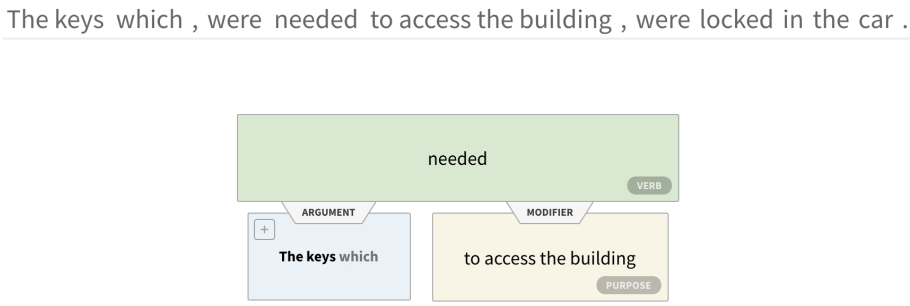

Fig. 6: Ejemplo de la tarea SRL del sistema AllenNLP tomando el verbo *"need"* como verbo principal.

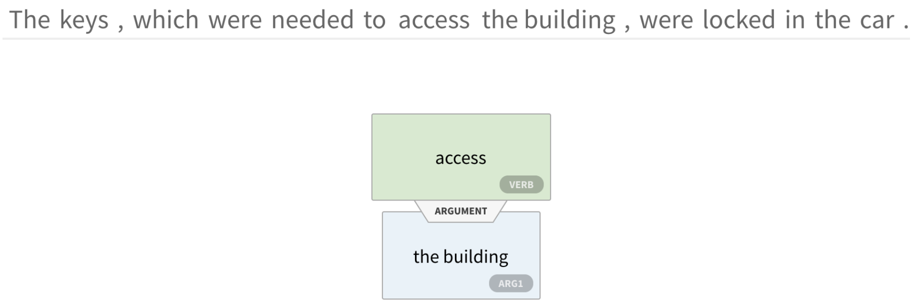

Fig. 7: Ejemplo de la tarea SRL del sistema AllenNLP tomando el verbo *"access"* como verbo principal.

[16] `https://demo.allennlp.org/semantic-role-labeling`

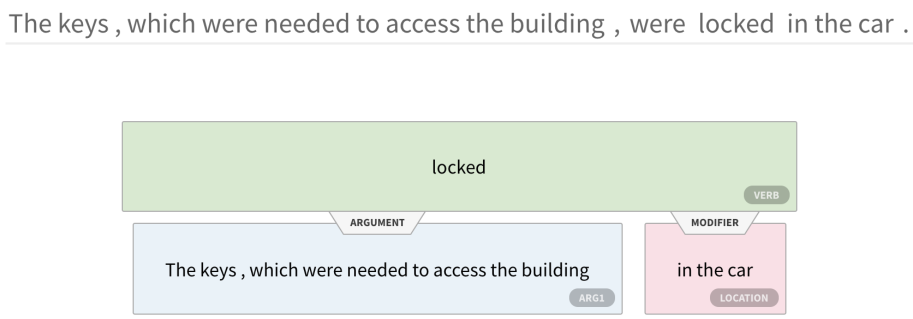

Fig. 8: Ejemplo de la tarea SRL del sistema AllenNLP tomando el verbo *"lock"* como verbo principal.

were: The keys , which [V: were] needed to access the building , were locked in the car .

needed: [ARG1: The keys] , [R-ARG1: which] were [V: needed] [ARGM-PRP: to access the building] , were locked in the car .

access: The keys , which were needed to [V: access] [ARG1: the building] , were locked in the car .

were: The keys , which were needed to access the building , [V: were] locked in the car .

locked: [ARG1: The keys , which were needed to access the building] , were [V: locked] [ARGM-LOC: in the car] .

Fig. 9: Mismo ejemplo que 6, 7, 8 de la tarea SRL del sistema AllenNLP pero con todas sus interpretaciones posibles.

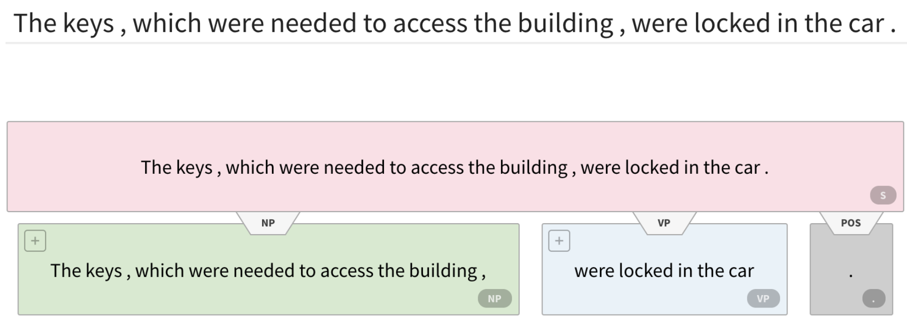

Fig. 10: Ejemplo del analizador de constituyentes del sistema AllenNLP.

2.5. Técnicas híbridas

2.5.1. TakeFive

En [32] se introduce un nuevo sistema de SRL basado en FrameNet. Este método es un método híbrido y transforma un texto en un grafo de conocimiento orientado a marcos semánticos utilizando *Framester*[17]. Para ello realiza un análisis de dependencia, identifica las palabras que evocan marcos léxicos, localiza los roles y rellenos de cada marco, ejecuta técnicas de coerción y formaliza los resultados en grafos de conocimiento. El algoritmo principal de TakeFive se compone de cuatro pasos básicamente:

1. **Preprocesamiento**, en donde se extraen las dependencias y anotaciones de marco utilizando herramientas existentes (tales como CoreNLP y WFD – Word Frame Disambiguation –)
2. **Detectar roles de interfaz**.
3. **Detectar roles específicos** de *VerbNet* (principalmente semánticos) para un marco determinado.
4. **Comprobar la compatibilidad** entre la interfaz y los roles semánticamente específicos.

Este proyecto está escrito en Python y es de libre acceso[18].

[17] Framester es un grafo de conocimiento RDF que actúa como centro entre varios recursos lingüísticos orientados a predicados proporcionando de esta forma una gran cantidad de asignaciones lingüísticas que ayudan a una alineación semiautomática requiriendo un análisis lingüístico previo de las relaciones y su contexto.

[18] `https://github.com/TakeFiveSRL/TakeFiveSRL`

3. Planteamiento del problema

En este trabajo se plantea una aproximación al problema de la EE dentro del ámbito legal cumpliendo los objetivos presentados en la sección 1.2.

Se ha mencionado con anterioridad que este problema apenas ha sido estudiado, por lo que queda mucho campo por explorar. Debido a ello, a la enorme cantidad diferente de tipos de documentos legales que existen y al desconocimiento de las *"keywords"* referentes a este dominio, se ha decidido acotar el problema y optar por el estudio de las licencias.

Para ello ha sido necesario, en primer lugar, realizar un estudio de su estructura más simple hasta el modelo de datos REL[19] que siguen. Además, se ha estudiado un conjunto de licencias para comprender la nomenclatura usada.

Tras este primer estudio y el entendimiento de los textos a ser tratados, se ha procedido al estudio práctico de algunas técnicas destacadas en la sección anterior (2.3, 2.4 y 2.5). Las dificultades encontradas en cada una de las tecnicas estudiadas para su expansión se explican en la siguiente sección, junto con su solución propuesta. Finalmente, como la expansión de estos sistemas ha resultado demasiado complicada, se ha optado por el desarrollo completo de un sistema en el que, dada cualquier licencia escrita en inglés, proporcione un RDF válido.

3.1. Dificultades encontradas y soluciones propuestas

En la siguiente tabla [6] se recoge el conjunto de dificultades encontradas a cada paso y su solución propuesta para el estudio – desde un punto práctico – del problema.

[19] *REL (Rights Expression Language)* es un conjunto de lenguas ideadas para expresar condiciones de uso de contenido digital. Los REL más relevantes en este campo son ODRL y MPEG-21 REL.

ID	Tipo	Descripción
1	Dificultad	En un primer mometo se optó por intentar expandir OPEN-SESAME debido a sus buenas críticas, su novedad, precisión y reciente actualización por parte de su desarrollador. Pero, tras comprobar la lentitud del sistema, la cantidad de subtareas que se debían realizar antes de obtener el resultado final, que solo trabajaba frase a frase y la falta de comprensión de la salida final, se rechazó esta idea.
	Solución	Se descartan los sistemas basados por completo en reglas y se pasa al estudio de los sistemas basados en datos.
2	Dificultad	En un segundo intento se probó AllenNLP debido a que parecia ser el más actual y el que incorporaba un mayor número de mejoras. El problema principal es que proporcionaba información demasiado escasa, debía ir frase a frase y no reconocía casos legales.
	Solución	Se descartan los sistemas basados por completo en datos y se pasa al estudio de los sistemas híbridos.
3	Dificultad	En un tercer intento se opta por TakeFive, un sistema bastante novedoso que parece incorporar lo mejor de los métodos basados en reglas y de los basados en datos. En este tercer caso la solución es bastante completa: identifica todos los verbos que aparecen en la oración, junto con su lema, POS, caracter tanto de inicio como de fin y marco/s identificados. Además, es capaz de identificar relaciones como sujeto, CD, SPrep, etc.; y permite proporcionar como entrada al sistema más de una oración. El principal problema en este caso es que apenas reconoce *frames* legales.
	Solución	Se descartan los sistemas híbridos debido a la falta de tiempo para su estudio y la posible expansión (o no) del sistema. Para ello se propone la creación de un nuevo sistema que sea capaz de identificar los casos legales.
4	Dificultad	Debido a la opción final de la creación del sistema, se propone en un primer momento realizar el proyecto teniendo en cuenta tanto el inglés como el español. Esta consideración fue tomada en cuenta debido a que el español es la lengua nacional. Esta idea pronto fue rechazada debido a la falta de licencias escritas en este idioma, lo que imposibilita su testeo.
	Solución	Se decide realizar este proyecto teniendo en cuenta tan solo el inglés, dejando su posible expansión al español para un futuro.

Tab. 6: Dificultades encontradas y soluciones propuestas

4. Experimento

4.1. Estudio de las licencias

Para poder realizar este experimento ha sido necesario comprender las licencias, su estructura y los tipos que hay. Una licencia es un contrato mediante el cual una persona recibe de otra el derecho de uso, copia, distribución, estudio y modificación (en el caso del Software Libre) de varios de sus bienes, normalmente de carácter no tangible o intelectual, pudiendo darse a cambio del pago de un monto determinado por el uso de los mismos. Estos activos son propiedad del otorgante, y pueden ser bienes de propiedad intelectual como una marca, patentes o tecnologías. También pueden ser objeto de licencia otros bienes de carácter intangible como la distribución de obras intelectuales.

La modalidad de licenciamiento es muy común en la industria del software, donde se comercializan *licencias de software* que permiten el uso de un programa o aplicación computacional sin ser uno el dueño, por lo que no se tiene la propiedad para venderlo, ni arrendarlo o modificarlo (o si, en el caso del Software Libre).

Existen también licencias con características especiales, que permiten la modificación o transmisión del software. Estas licencias se suelen denominar *freeware* (de uso gratuito), *shareware* (de distribución gratuita) o las que se permite la modificación del software: *software libre* y *software de código abierto*.

4.1.1. Estructura de una licencia

La estructura principal que sigue cualquier licencia se puede ver reflejada en 11, donde:

- **Issuer**: identifica a quien emitió/creó la licencia.
- **Principal**: encapsula la identificación de una parte a la que se otorgan *Rights*. Cada *Principal* identifica exactamente una parte, es decir, una entidad única involucrada en la concesión o ejecución de *Rights*.
- **Right**: “verbo”que un *Principal* puede ejercer contra algún *Resource* bajo alguna *Condition*. Por lo general especifica alguna acción, actividad o clase de acciones.
- **Resource**: “objeto.ªl que se le puede otorgar un *Right* a un *Principal*. Puede ser un trabajo digital, un servicio o una información que un *Principal* puede poseer.
- **Condition**: especifica los términos gramaticales, condiciones y obligaciones bajo los cuales se pueden ejercer *Right*.

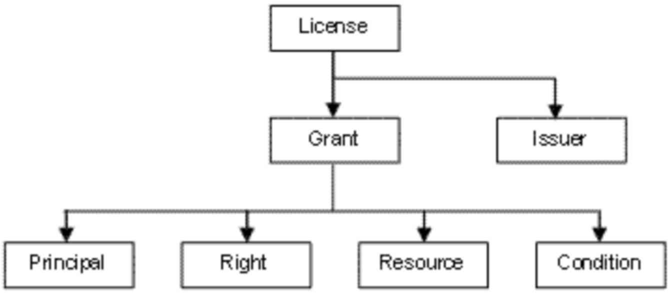

Fig. 11: Estructura básica de una licencia.

Además, el modelo de datos REL que sigue la sub-estructura compuesta por los elementos *"principal"*, *"right"*, *"resource"* y *"condition"* de una licencia se puede apreciar en 12.

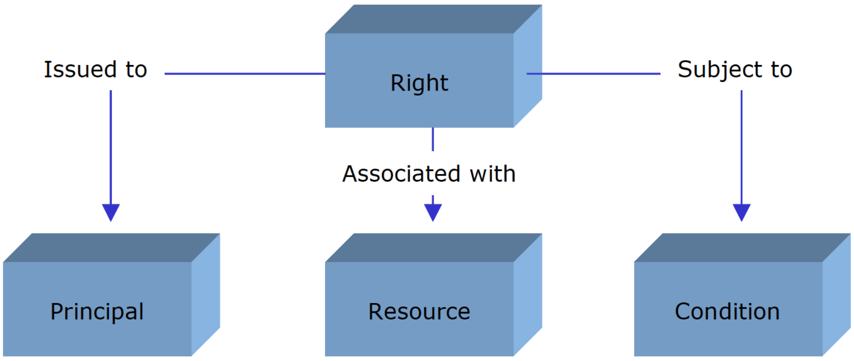

Fig. 12: Estructura del modelo de datos REL de una licencia.

4.1.2. Tipos de licencias

- **Licencias de Software Libre**: ofrece al consumidor el código fuente original y le otorga la facultad de usarlo, modificarlo y distribuirlo (con o sin modificaciones). El hecho de que sea *libre* no implica que sea gratuito ni que esté exento de regulaciones legales. La filosofía detrás de este tipo de licencia se encuentra sustentada en el beneficio a la comunidad; esto, a través de la retroalimentación y colaboración entre programadores. Un ejemplo de este tipo de software es el Kernel de Linux; el cual ha sido usado por la comunidad como pieza angular en el diseño de sistemas operativos que operan bajo esta licencia. A su vez, está licencia puede subdividirse en otras que contienen cláusulas más especifícas y se regulan principalmente por *copyleft*[20].

[20] El **copyleft** es una versión del *copyright* y sirve para regular las licencias de software libre. Su función principal es impedir que sea usado el código fuente sin autorización definiendo las condiciones bajo las cuales se puede hacer uso de él.

- **Licencia de Software libre sin protección Copyleft**: autoriza a terceros para no solo modificar el producto; si no también, para poder licenciar el mismo bajo sus propios términos. Esto puede provocar, que un software libre hecho a partir de tu obra y que estaba destinado a apoyar la comunidad; pueda ser privatizado por algún desarrollador que lo modifique.

- **Licencia de Software libre con protección Copyleft**: obliga a que los programadores que quieran redistribuir tu código deban seguir los lineamientos y restricciones que se les haya impuesto. Por ejemplo, si tu código es de acceso, modificación y distribución libre; los que se deriven de él también deben estar licenciados bajo los mismos términos y no podrían ser privatizados.

- **Licencias GPL (Licencia Pública General Reducida de GNU)**: es un ejemplo de software libre con protección copyleft. Sus términos le permiten integrarse con módulos de software no libre y también poderse comercializar.

- **Debian (Debian Free Software Guidelines)**: se trata de una licencia para software libre que posee lineamientos bastante estrictos en cuanto a la distribución del código ya que exige que cualquier distribuición hecha bajo la licencia Debian deba estar acompañada de su código fuente y ser libre. Así mismo, se menciona que estos lineamientos no deben variar dependiendo del sitio donde se encuentre y que cualquier proyecto derivado debe ser puesto bajo la misma licencia. Esta licencia no tiene permitido discriminar a ninguna persona o grupo de personas y no puede "contaminar.ºtro software.

- **BSD (Distribución del Software Berkeley)**: es considerada como una de las más permisivas dentro del software libre ya que a pesar de imponer restricciones, no se compara en absoluto con los casos anteriores. Los principales lineamientos de está licencia son (1) libertad para poder comercializar el software libremente, (2) libertad para poder compartir tu código fuente libremente (o no), y (3) garantización del crédito para los desarrolladores que participan en su elaboración.

- **Licencia tipo MPL**: se asemeja a la licencia BSD, siendo esta menos permisiva con las distribuciones. Es considerada como un término medio entre licencias BSD y licencias GNU. Sus lineamientos obligan a entregar al creador original del código tus modificaciones y permite licenciar solo los archivos binarios.

- **X.Org**: se trata de una licencia *híbrida*, ya que puede ser aplicada tanto a software libre como a software que no lo es. Sus lineamientos no están apegados al copyleft. Su principal exponente es X Windows System, un sistema que nació para dotar de interfaz gráfica a los sistemas basados en Unix y actualmente se encuentra en uso la versión 11 (X11).

- **Licencia de Dominio Público**: puede no considerarse incluso como una licencia ya que no tiene ningún tipo de restricción hacia el usuario final. Su código puede ser modificado, usado y distribuido por cualquiera, y los usuarios tienen la capacidad de licenciar sus redistribuciones libremente como mejor les convenga.

- **Software Semi-Libre**: ofrece el contenido al consumidor de forma gratuita para su uso, distribución, copia e incluso, en algunos casos se le permite hacer modificaciones. Sin embargo, no se considera software libre y no permite que se pueda lucrar con dicho material (ya sea una copia o modificación).
- **Licencia Freeware**: se trata del libre derecho al uso y copia de un software bajo los términos que defina el autor de dicho programa sin permitir bajo ninguna condición su modificación o venta por parte de terceros. Un ejemplo de este tipo de licencia, son aplicaciones como CCleaner, Adobe Flash o Adobe Reader. Estos tipos de licencia pueden tener variantes especifícas como:
    - **Licencia Donationware**: ofrece al usuario todos los derechos que la licencia Freeware; sin embargo, se le invita a realizar un donativo en favor de continuar el desarrollo de dicha aplicación. Este donativo no es obligatorio y tampoco condiciona al uso del producto.
    - **Licencia Postcardware**: invita al usuario para enviar una carta postal una vez adquirido el producto. Pero al igual que con la licencia Donationware, no es un requisito oblitario de cumplir y/o que condicione al uso del software en cuestión.
- **Licencia Shareware**: se puede subdividir en otras debido a sus condiciones, ya que permite al usuario poder hacer uso de los programas por un tiempo limitado; o, en algunos casos puede usarse permanentemente, pero con funciones limitadas. Un obstáculo que solo puede ser sorteado si se paga una cierta cantidad por la versión completa. No permite ningún tipo de modificación al no incluir su código fuente. Los tipos de licencia que abarca son:
    - **Trial**: es el nombre que se le da a la licencia de un programa de pago que tiene todas sus funciones activas; pero, solo por un período de tiempo limitado. Por ejemplo la paquetería de Adobe, Sony Vegas, Kaspersky, etc.
    - **Demo**: este tipo de licencia se presenta a menudo en los videojuegos; ya que permite al usuario hacer uso del producto por tiempo indefinido, pero con la mayoría de sus funciones restringidas.
    - **Adware**: está clasificación se le da a aquellos programas comerciales que se pueden utilizar de forma gratuita; pero que a cambio, descargan publicidad o que cuentan con versiones más avanzadas del mismo producto que requieren de ser compradas. Este modelo es común en los móviles; donde existen las versiones de pago, libres de publicidad y las gratuitas

que están inundadas de banners promocionales, o piden descargar otras aplicaciones que se publicitan para continuar usándola.

- **Licencia CRIPPLEWARE**: sirve para clasificar a todos aquellos programas cuyas funciones se encuentran limitadas frente a la versión "completa.º avanzada. Es muy común en el caso de antivirus con sus versiones lite u otros software que buscan ser de utilidad en equipos viejos, con un hardware mucho más limitado.

- **Licencia Abandonware**: este es un caso particular que implica que un proyecto ha sido abandonado por su autor, y éste ha decidido liberarlo de todos los derechos de copyright. Al pasar esto, los productos suelen ser retirados del mercado y tomados por desarrolladores independientes, quienes se encargan de realizar modificaciones y compartirlas con la comunidad.

- **Licencia Careware**: es similar a la *licencia Donationware*. En este caso se solicitan donativos no para financiar el proyecto, si no para apoyar causas humanitarias, caridad y otras campañas relacionadas. El software bajo este tipo de licencia permite al usuario poder copiarlo y modificarlo sin restricciones, y normalmente son distribuidos de forma gratuita, por lo que los donativos suelen ser opcionales y no obligatorios.

- **Licencia de Software Propietario**: se trata de una clasificación donde el autor del proyecto limita los derechos de copia, modificación y redistribución de su proyecto; y en caso de que el usuario final desee llevar a cabo cualquiera de estás acciones, requiere pagar una cierta cantidad al autor para tener derecho a hacerlo.

- **Licencia de Software Comercial**: se le otorga este tipo de licencia a todo aquel software desarrollado con intenciones de ser comercializado. Podría ser fácilmente confundido con el software propietario. Sin embargo, existe software comercial que puede ser libre o propietario, así como existe software que no es libre y tampoco es comercial.

- **Licencia de Software Retail**: es el tipo de licencia que se vende normalmente; y dota del derecho al usuario final para poder instalarlo de forma ilimitada, cederlo a un tercero o incluso venderlo. Aquí podemos englobar a la mayor parte del software que vemos a la venta en tiendas especializadas.

- **Licencia de Software OEM**: establece como principal condición de distribución que se instale en un equipo nuevo. Por lo tanto, prohibe su venta bajo bajo otras circunstancias que difieran de esta condición; y por lo regular, se aplica a los sistemas operativos. En cuanto a su reutilización, el software puede variar en condiciones; ya que, existen algunos que limitan el número de veces que puede ser reinstalado. Cualquier software que opere bajo estás condiciones debe ser idéntico a aquellos que utilicen la licencia tipo Retail; y tampoco se pueden ceder a terceros, a menos que se dé como parte del equipo.

- **Licencia de Software de Volumen**: se negocian frecuentemente con grandes empresas y operan bajo la normativa de OEM; excluyendo la condición de que sean equipos nuevos. A menudo, se estipula una cantidad determinada de equipos que podrán utilizar la misma licencia dentro de una empresa; y la distribuidora del software tiene la capacidad de realizar comprobaciones para ver si sus licencias están siendo usadas bajo los términos acordados. Una condición de estos tipos de licencia, es que no pueden venderse ni cederse a terceros bajo ninguna circunstancia.

4.2. Corpus

Para el desarrollo del proyecto, asi como para su posterior evaluación, ha sido necesario descargar dos corpus diferenciados, uno para cada fase. Ambos corpus han sido obtenidos de la página Web `http://rdflicense.appspot.com/#2`, seleccionando una gran variedad de licencias de diferentes tipos en la medida de lo posible. Esta página Web contiene un total de 183 licencias junto con su representación RDF de diferentes licencias para datos, software u obras generales.

4.2.1. Corpus de estudio

El entrenamiento se ha realizado con un total de 10 licencias diferentes (ver 7). El conjunto de licencias seleccionadas en este caso se ha recogido en el anexo B.

Licencias seleccionadas
Creative Commons CC_BY_NC 4.0
Creative Commons CC_BY_SA 2.0
Creative Commons CC_BY 3.0
GNU Public License 1.0
BSD License Definition 2.0
IBM Public License 1.0
MIT License 1.0
Cryptix General License
European Union Public License 1.1
Eclipse Public License 1.0

Tab. 7: Corpus de estudio

4.2.2. Corpus de evaluación

La evaluación se ha realizado con un total de 10 licencias diferentes (ver 8). El conjunto de licencias seleccionadas en este caso se ha recogido en el anexo C.

Licencias seleccionadas
Creative Commons CC_BY_NC_ND 4.0
W3C Software Notice and License 1.0
Apache License 2.0
Open Government License Non-Comercial 2.0
ColorIURIS Copyright
Oracle Berkely DB License 1.0
BOOST Sotfware License 1.0
Mozilla Public License 2.0
Creative Commons CCo 1.0
Artistic License 2.0

Tab. 8: Corpus de evaluación

4.3. Implementación

El experimento realizado en este trabajo ha sido implementado y publicado en un repositorio software de Github[21]. El código fuente es de tipo código abierto y su funcionamiento básico es el siguiente (Ver 13):

- **Entrada al sistema**: se corresponde con un texto en *lenguaje natural* que contiene el texto referente a una licencia cualquiera completa escrita en inglés.
- **Salida del sistema**: se corresponde con un RDF, el cual debe ser válido, y que contiene toda la información referente a dicha licencia de forma clara y concisa. En este caso se identifica de manera inmediata el nombre de la licencia, la versión y el conjunto de acciones que están permitidas, prohibidas y que son requeridas o solicitadas. La plantilla a ser rellenada por los siete componentes básicos se puede observar en 14.
- **Almacenamiento persistente interno al sistema**: el conjunto de archivos que forman parte del almacenamiento persistente es el siguiente:
    - *en-sent.bin*: detector de frases de origen inglés entrenado con datos de entrenamiento de OpenNLP.
    - *en-pos-maxent.bin*: etiquetador POS del inglés que contiene el modelo maxent con el diccionario de etiquetas.
    - *en-lemmatizer*: diccionario en inglés que contiene cada una de las palabras junto con su etiqueta correspondiente y su lema asociado. Por ejemplo *permitted VBN permit* o *reproduce VBP reproduce.*

[21] `https://github.com/aidita/LegalExtractor`

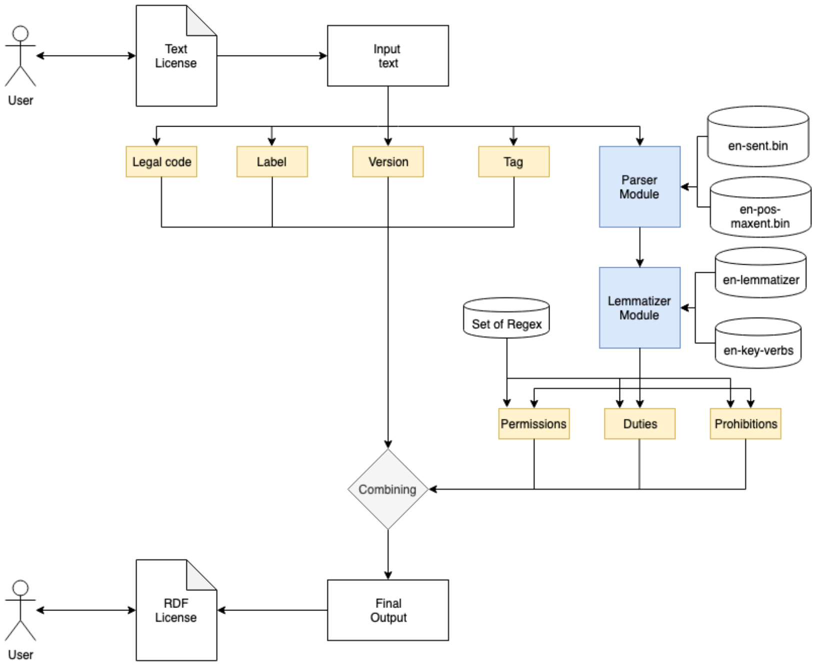

Fig. 13: Diagrama de flujo de los principales componentes.

- *en-key-verbs*: lista de los verbos principales que detectan acciones importantes referentes a las licencias. Por ejemplo *adapt, copy, distribute, modify, rent* o *sell.*

- *Regex*: conjunto de expresiones regulares que identifican cada una de las acciones o propiedades que son estudiadas. Ha sido necesario acotar y restringir este conjunto debido a su gran amplitud. En un primer momento se tuvieron en cuenta todas las propiedades referentes a **Creative Commons** debido a que eran muy reducidas [9]. Más tarde y dado que algunas de estas propiedades apenas aparecían en las licencias estudiadas, se decidió prescindir de algunas de ellas (*Sharing* y *Copyleft* porque solo aparecen en una del total de 20 licencias; y *Lesser Copyleft* y *High Income Nation Use* porque no aparecen en ninguna de las 20 licencias). Finalmente y en virtud de la continuada repetición de algunas propiedades diferentes referentes a **ODRL**, se amplían estas propiedades en la sección **Permission** con *odrl:modify, odrl:sell* y *odrl:lease*; formando el conjunto final de propiedades estudiadas.

▪ **Módulos internos al sistema**: el sistema tiene dos módulos internos principales que se encargan de realizar las tareas principales referentes al NLP.

- *Parser Module*: este módulo es el encargado de realizar las siguientes tareas: (1) dividir el texto por frases, (2) etiquetar cada palabra de cada

```
@prefix cc:      <http://creativecommons.org/ns#> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix odrl:    <http://www.w3.org/ns/odrl/2/> .

<http://purl.org/NET/rdflicense/TAG>
      a       odrl:Policy ;
      rdfs:label "LABEL" ;
      dct:hasVersion "VERSION" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
      odrl:permission
              [ odrl:action PERMISSIONS ;
                odrl:duty
                        [ odrl:action DUTIES
                        ]
              ] ;
      odrl:prohibition
              [ odrl:action PROHIBITIONS
              ] ;
cc:legalcode """

LEGAL CODE

"""@en .
```

Fig. 14: Plantilla de la salida del sistema.

frase y (3) identificar y guardar los verbos de cada frase para que el módulo lematizador los procese. Esta última tarea requiere guardar la información tanto de la palabra (verbo), así como la frase en la que se encuentra y su etiqueta asociada.

- *Lemmatizer Module*: este módulo es el encargado de realizar las siguientes tareas: (1) obtener los lemas de cada uno de los verbos de cada frase, (2) comprobar si estos verbos están contenidos en la lista de verbos clave (*en-key-verbs*) y (3) devolver solo y exclusivamente el conjunto de oraciones que contienen verbos clave para ser estudiadas y buscar las propiedades descritas anteriormente.

- **Componentes básicos**: hay un total de siete componentes básicos. Estos componentes son los que, tras combinarse, formarán parte de la salida. Los cuatro primeros componentes se extraen directamente de la entrada al sistema, mientras que los tres últimos se obtienen tras procesar el texto de entrada por los módulos parseador (*Parser Module*) y lematizador (*Lemmatizer Module*). Para poder obtener estos tres componentes además de su procesamiento se necesita el conjunto de expresiones regulares (*Regex*).

Clase	Descripción	Propiedad	Descripción
Permission	Acción que puede ser permitida o deseada.	cc:Reproduction	Se permite hacer múltiples copias.
		cc:Distribution	Se permite distribución, exhibición y desempeño público.
		cc:DerivativeWorks	Se permite la distribución de trabajos derivados.
		cc:Sharing	Se permiten derivados comerciales pero solo distribución no comercial.
Requirement	Acción que puede ser requerida o solicitada	cc:Notice	Los avisos de copyright y licencia se mantienen intactos.
		cc:Attribution	Se otorga crédito al titular del copyright y/o autor.
		cc:ShareAlike	Los trabajos derivados se licencian en los mismos términos (o términos compatibles) que el trabajo original.
		cc:SourceCode	Se debe proporcionar el código fuente al ejercer algunos derechos otorgados por la licencia.
		cc:Copyleft	Los trabajos derivados y combinados deben tener una licencia bajo términos específicos similares a los del trabajo original.
		cc:LesserCopyleft	Los trabajos derivados deben tener licencia en términos específicos con al menos las mismas condiciones que el trabajo original; las combinaciones pueden ser licenciadas bajo diferentes términos.
Prohibitions	Algo que puede prohibirse.	cc:CommercialUse	Ejercer derechos con fines comerciales.
		cc:HighIncome NationUse	Su uso en un país no desarrollado.

Tab. 9: Propiedades relacionadas con las licencias Creative Commons

- *Legal Code*: mismo texto de entrada al sistema.
- *Label*: nombre de la licencia. Por ejemplo *IBM Public License* o *Creative Commons Attribution*.
- *Version*: versión de la licencia estudiada. Si no es capaz de encontrarla, identificará la licencia con la versión 1.0 por defecto.
- *Tag*: etiqueta que identifica de manera única cada licencia. Está formada por el conjunto de *Label* y *Version*.
- *Permissions*: conjunto de acciones que están permitidas.
- *Duties*: conjunto de acciones que puede ser solicitadas o requeridas. Es el equivalente a la clase *Requirement*.
- *Prohibitions*: conjunto de acciones que pueden estar prohibidas.

4.4. Ejecución del código

El código principal puede encontrarse en `https://github.com/aidita/LegalExtractor` y está organizado como se puede observar en 15. Para ejecutar el código es necesario:

- Pre-requisitos: última versión de Java, NetBeans 8.2 (versión utilizada).
- Descargar el código desde GitHub o clonar el repositorio en el ordenador.
- La clase main.java puede ejecutarse directamente con la información presente. Si se desea introducir alguna otra licencia cualquiera tan solo debe guardarse en un archivo de texto (no es necesario especificar su extensión) y sustituir la ruta del main por la que tenga el nuevo archivo guardado. También hay un conjunto de otros nueve archivos de prueba que pueden ser ejecutados cambiando el final de la ruta especificada como 1.txt por cualquiera de los archivos [2-10].txt.
- La salida deberá obtenerse en el escritorio en un archivo llamado license.rdf. El contenido del archivo debe ser similar al que se muestra en 16

Nota: el tiempo de ejecución no debería exceder los 12 segundos ya que en todas las pruebas realizadas (ya sean en los 10 corpus de estudio o en los 10 corpus de prueba) jamás se ha llegado a ese tiempo en ninguna de sus ejecuciones (habiendo realizado una media de cuatro ejecuciones por archivo).

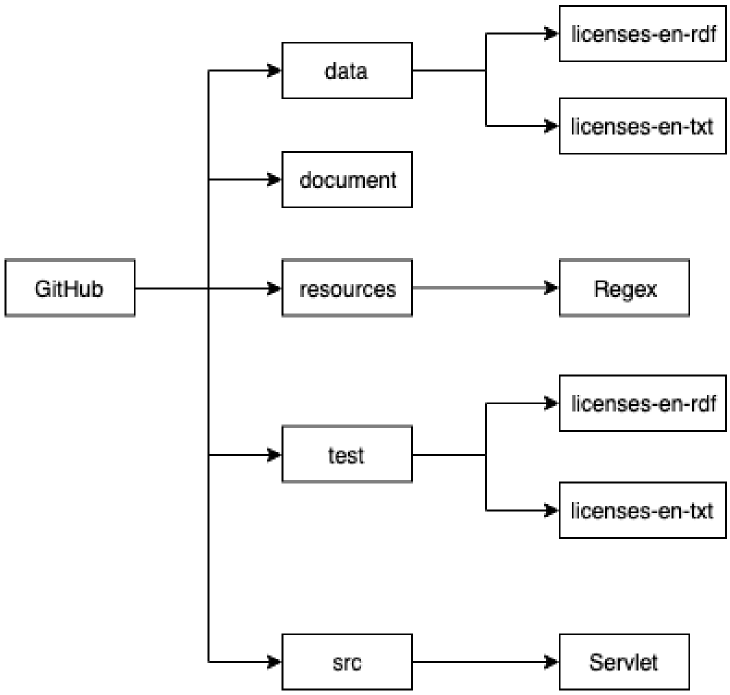

Fig. 15: Organización de las carpetas principales del código en GitHub.

```
@prefix cc:      <http://creativecommons.org/ns#> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix odrl:    <http://www.w3.org/ns/odrl/2/> .

<http://purl.org/NET/rdflicense/cryptixgenerallicense1.0>
      a       odrl:Policy ;
      rdfs:label "cryptix general license" ;
      dct:hasVersion "1.0" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
      odrl:permission
              [ odrl:action cc:Distribution , odrl:modify  ;
                odrl:duty
                        [ odrl:action cc:Notice
                        ]
              ] ;
cc:legalcode """
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BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY,
WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE
OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN
IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

"""@en .
```

Fig. 16: Ejemplo de la salida final del sistema.

4.5. Metodología de evaluación

Para evaluar el sistema creado se ha usado un método general conocido. Los resultados se han definido en cuatro clases [10]:

- **Verdaderos Positivos (VP)**: objetos positivos marcados como positivos.
- **Verdaderos Negativos (VN)**: objetos negativos marcados como negativos.
- **Falsos Positivos (FP)**: objetos negativos marcados como positivos.
- **Falsos Negativos (FN)**: objetos positivos marcados como negativos.

		Valor en la realidad	
		Positivo	Negativo
Valor predictivo	Positivo	Verdadero Positivo	Falso positivo
	Negativo	Falso Negativo	Verdadero Negativo

Tab. 10: Clases principales en las que se han dividido los datos del experimento

El método está basado en las siguientes métricas:

- **Exactitud**: observaciones predichas de forma correcta del conjunto de observaciones totales.
  Exactitud = (VP+VN) / (VP+FP+FN+VN)
- **Precisión**: medida de la verdad, que todos los objetos marcados como positivos realmente son positivos.
  Precisión = VP / (VP+FP)
- **Sensibilidad**: (o ratio de verdaderos positivos) medida de la verdad, que todos los objetos positivos estén marcados.
  Sensibilidad = VP / (VP+FN)
- **Medida-F o Valor-F**: medida de precisión que tiene un test. Se emplea en la determinación de un valor único ponderado de la precisión y la sensibilidad.
  *Medida-F = 2 * (Precisión * Sensibilidad) / (Precisión+Sensibilidad)*
- **Especificidad**: (o ratio de falsos positivos) medida de la falsedad, más conocido como *fall-out* en la extracción y recuperación de la información.
  Especificidad = FP / (FP+VN)
- **Curva ROC**: representación gráfica de la sensibilidad frente a la especificidad para un sistema clasificador binario. En otras palabras, representa el ratio de verdaderos positivos (en principio, beneficios) frente al ratio de falsos positivos (en principio, costes). En este caso los puntos por encima de la diagonal son buenos (cuanto más por encima mejor) y los puntos por debajo de la diagonal son malos (cuanto más por debajo peor).

Debe tenerse en cuenta que hay un amplio conjunto de propiedades que han quedado fuera del estudio por motivos de tiempo, y esto ocasiona que muchos de los *FN* se deban a la mala cobertura del sistema. Este es uno de los principales puntos que deben ampliarse en posibles líneas futuras.

Además, no hay muchos trabajos previos que se centren en el mismo problema. Por lo que ha sido casi imposible su comparación con otros sistemas desarrollados.

4.6. Resultados obtenidos

En esta sección se describen los resultados obtenidos al ejecutar el código del conjunto de 20 corpus. Estos resultados se han comparado con los obtenidos de `http://rdflicense.appspot.com/`. El experimento ha sido ejecutado en un MacOS Mojave (v. 10.14.5) 2,7GHz intel core i5 8.00GB.

En vista a los resultados obtenidos en 17, 18, 19, 20 y 21 se puede concluir que tal y como era de esperar los resultados obtenidos al trabajar con los datos de entrenamiento el resultado es bastante mejor que los obtenidos al trabajar con los datos de prueba. Esto es debido a que las reglas han sido extraidas del conjunto de corpus de entrenamiento, por lo que es normal que tanto su exactitud como su precisión no bajen del 85 %, obteniendo en la mayoría de los casos (90 %) una exactitud del 90 % o superior y una precisión del 100 %. Sin embargo, al trabajar con los datos de prueba estos resultados empeoran llegando hasta un 55 % de exactitud y un 50 % de precisión en uno de los casos menos acertados. A pesar de ello cabe destacar que el 70 % de los datos de prueba superan o igualan el 80 % de exactitud y el 75 % de precisión sin problemas.

En cuanto a la sensibilidad (referente a la cobertura del sistema) en el peor de los casos en los datos de entrenamiento alcanza un 75 %; mientras que en los datos de entrenamiento tan solo un 30 % no alcanza este valor llegando en uno de ellos a alcanzar la cifra del 50 % (el valor más bajo obtenido). En virtud a estos resultados, la medida-F de los datos de entrenamiento es bastante aceptable (entre el 85 % y el 100 %) y la de los datos de prueba en el 70 % de los casos supera el 75 %, llegando en el peor de los casos al 60 %.

Finalmente, en cuanto a la curva ROC se puede concluir que los resultados obtenidos son, en cualquiera de los casos, mejores (o beneficiosos) con respecto a una suposición aleatoria de los datos, ya que en todos ellos supera la diagonal. Al igual que en los casos anteriores, los resultados obtenidos con los datos de entrenamiento son mejores que los datos de prueba, alcanzando en varios de los casos el resultado óptimo (situado en la esquina superior izquierda).

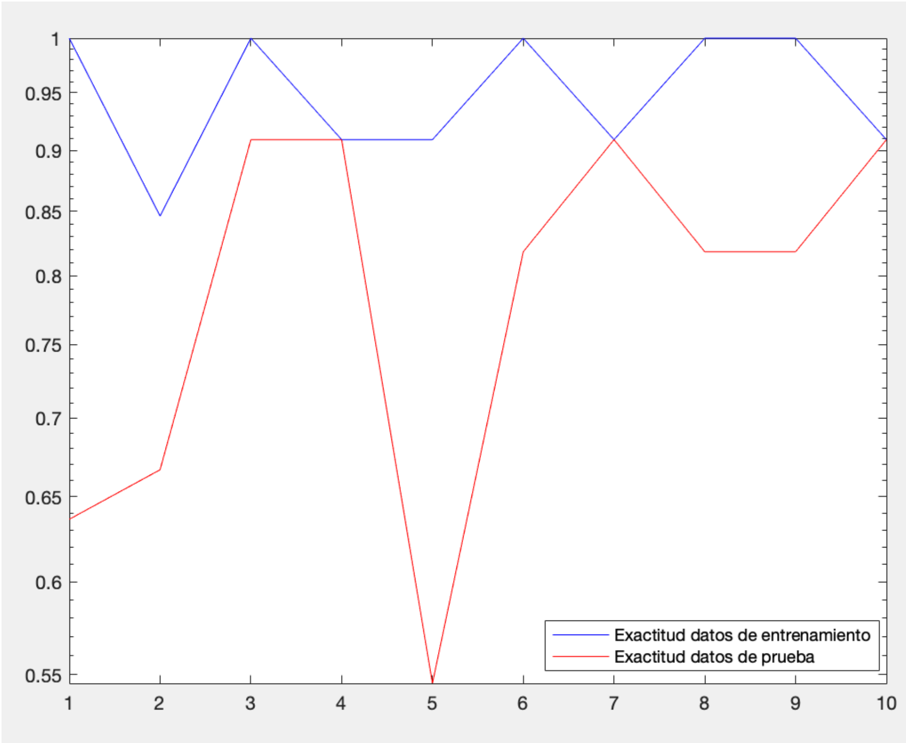

Fig. 17: Exactitud de las pruebas realizadas con los corpus de entrenamiento y de evaluación

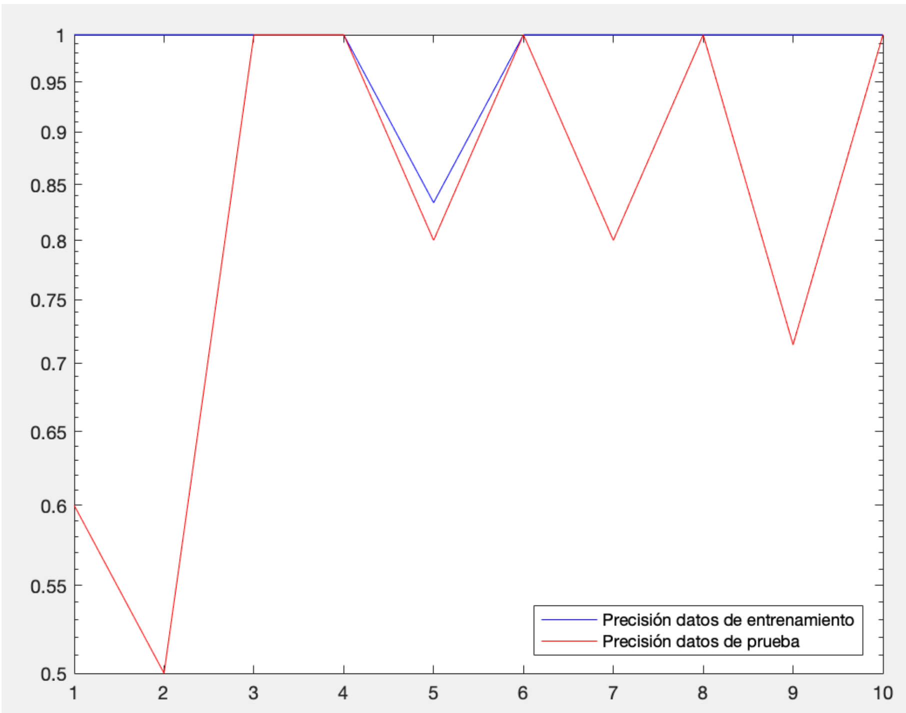

Fig. 18: Precisión de las pruebas realizadas con los corpus de entrenamiento y de evaluación

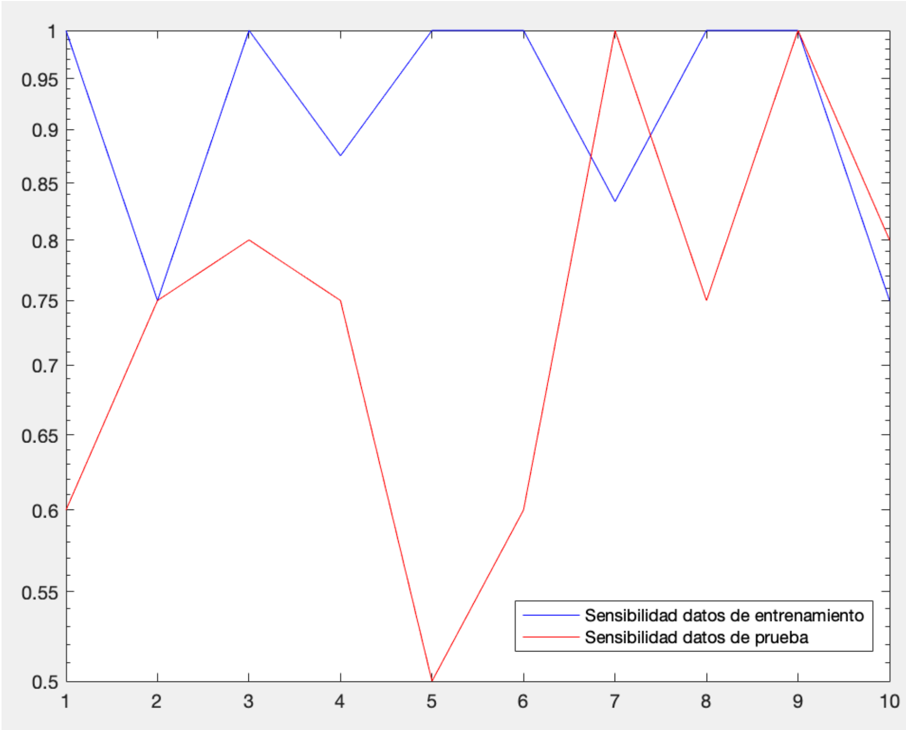

Fig. 19: Sensibilidad de las pruebas realizadas con los corpus de entrenamiento y de evaluación

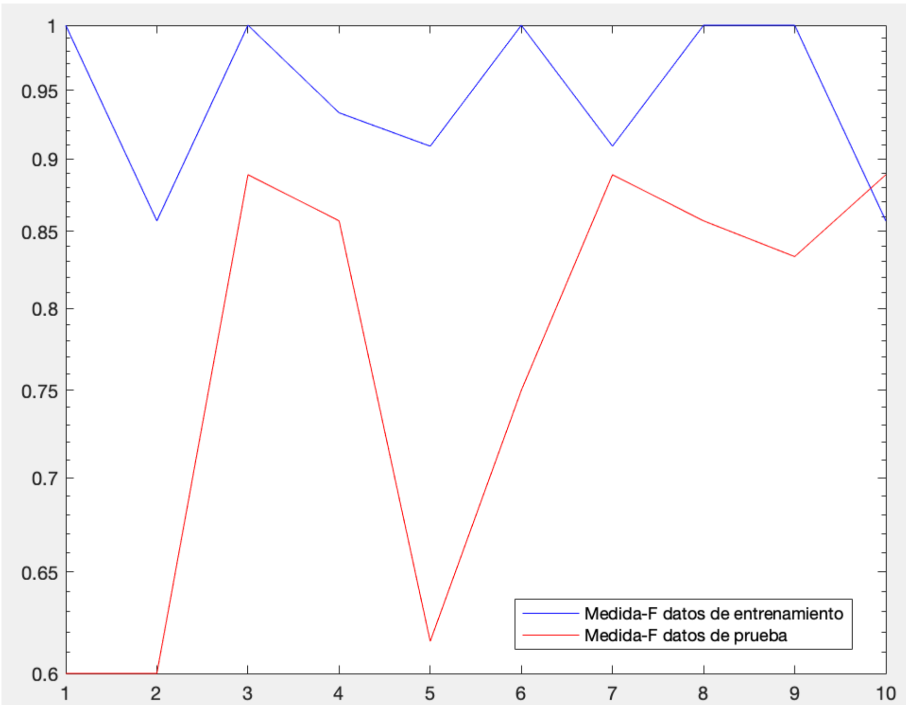

Fig. 20: Medida-F o Valor-F de las pruebas realizadas con los corpus de entrenamiento y de evaluación

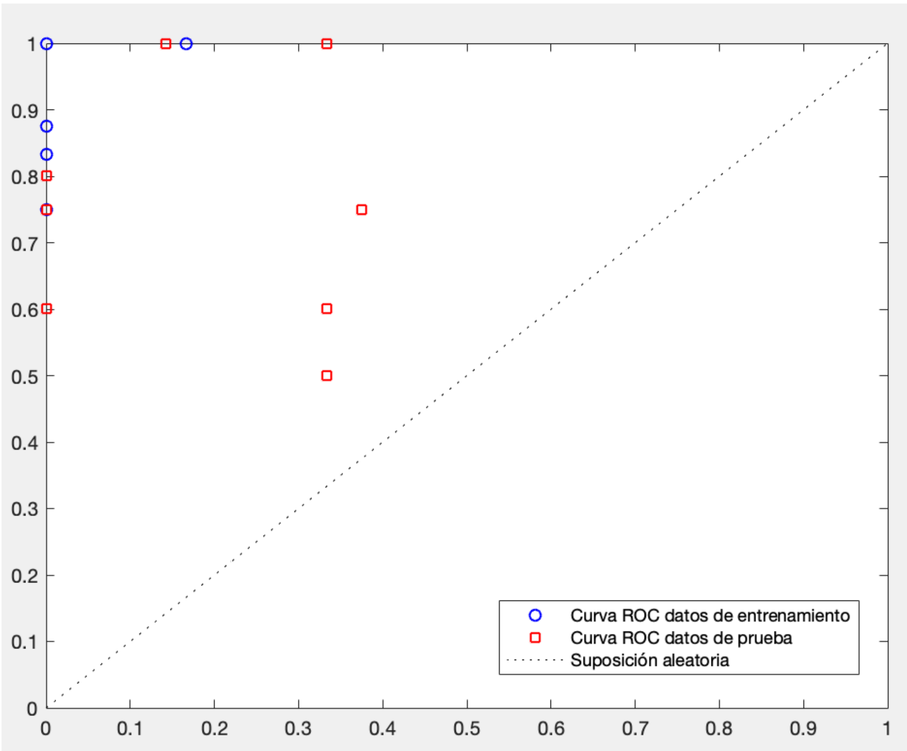

Fig. 21: Curva ROC de las pruebas realizadas con los corpus de entrenamiento y de evaluación

5. Conclusiones y líneas futuras

5.1. Conclusiones

Este trabajo presenta una nueva herramienta capaz de crear un RDF a partir de texto escrito en lenguaje natural. Dicho RDF contiene los elementos básicos de una licencia, es decir, el nombre, la versión, los permissions (o acciones permitidas), los requirements/duties (o acciones requeridas o solicitadas) y los prohibitions (o acciones prohibidas/no permitidas); así como el texto o código legal de la licencia. Cabe destacar que la extracción de las acciones no ha resultado una tarea sencilla ya que ha conllevado un estudio de las expresiones regulares típicas utilizadas. Al estar las licencias escritas en lenguaje natural esta tarea puede llegar a resultar muy compleja, ya que puede haber cientos de formas de expresar una única propiedad. Es por ello que la cobertura del sistema, a pesar de intentar ser lo mejor posible, no es óptima.

Por otra parte, debido al gran número de propiedades existentes para determinar las acciones posibles, se ha tenido que realizar una acotación de las mismas tomando como estudio tan solo aquellas referentes a los vocabularios de CC REL y ODRL que aparecen un mayor numero de veces.

En cuanto al estudio realizado se puede concluir que la herramienta resulta, por lo general, bastante precisa. Aunque debería ser reevaluada con un corpus de mayor tamaño (variando, en la medida de lo posible, el tipo de licencias seleccionadas) para recoger un mayor numero de casos y expresiones regulares utilizadas a la hora de definir cada una de las propiedades. Para este caso de estudio sería aconsejable contar con la ayuda de un lingüista que se maneje en este campo, lo que haría este trabajo mucho menos complejo.

Finalmente, en cuanto a la evaluación del sistema, cada una de las pruebas realizadas ha sido constatada y comparada de manera manual con el resultado óptimo para poder comprobar su tasa tanto de éxito (acierto o beneficio) como de error (fallo o costes) a través de una curva ROC. Gracias a este estudio de la curva ROC se puede comprobar que en cualquiera de los casos el sistema ofrece beneficios ya que todos los valores superan (están por encima) de la diagonal. Ademas, se han comprobado también su exactitud, precisión y sensibilidad; obteniendo a partir de estos dos últimos valores la medida-F o valor-F, la cual hace referencia a la precisión global real del sistema, y situándola por encima del 60 %.

5.2. Líneas futuras

Hay varias líneas de trabajo futuro abiertas. La primera de ellas es, tal y como se ha resaltado en el punto anterior, ampliar el corpus de estudio para obtener un mayor numero de expresiones regulares que encajen con cada una de las propiedades. Otra línea de trabajo posible que también ampliaría la cobertura del sistema sería ampliar el vocabulario o numero de propiedades estudiadas. Por ejemplo, se ha observado que son bastante comunes las propiedades DCT (referentes a Dublin Core Metadata Terms) además de las provenientes de CC REL y ODRL (las estudiadas en este experimento).

Finalmente, la última línea de trabajo propuesta es la extensión de la herramienta a otros idiomas (como por ejemplo el español) para obtener una meyor funcionalidad y reusabilidad.

A. Penn Treebank. Lista alfabética de etiquetas POS

Number	Tag	Description
1	CC	Coordinating conjunction
2	CD	Cardinal number
3	DT	Determiner
4	EX	Existential *there*
5	FW	Foreign word
6	IN	Preposition or subordinating conjunction
7	JJ	Adjective
8	JJR	Adjective, comparative
9	JJS	Adjective, superlative
10	LS	List item marker
11	MD	Modal
12	NN	Noun, singular or mass
13	NNS	Noun, plural
14	NNP	Proper noun, singular
15	NNPS	Proper noun, plural
16	PDT	Predeterminer
17	POS	Possessive ending
18	PRP	Personal pronoun
19	PRP$	Possessive pronoun
20	RB	Adverb
21	RBR	Adverb, comparative
22	RBS	Adverb, superlative
23	RP	Particle
24	SYM	Symbol
25	TO	*to*
26	UH	Interjection
27	VB	Verb, base form
28	VBD	Verb, past tense
29	VBG	Verb, gerund or present participle
30	VBN	Verb, past participle
31	VBP	Verb, non-3rd person singular present
32	VBZ	Verb, 3rd person singular present
33	WDT	Wh-determiner
34	WP	Wh-pronoun
35	WP$	Possessive wh-pronoum
36	WRP	Wh-adverb

Tab. 11: Etiquetas POS del proyecto Penn Treebank

B. Corpus de estudio

En el presente anexo figuran el texto de cada una de las 10 licencias seleccionadas para entrenar el proyecto, así como su RDF correspondiente.

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```
@prefix cc:      <http://creativecommons.org/ns#> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix odrl:    <http://www.w3.org/ns/odrl/2/> .
@prefix foaf:    <http://xmlns.com/foaf/0.1/> .

<http://purl.org/NET/rdflicense/cc-by-nc4.0>
      a       odrl:Policy ;
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      rdfs:seeAlso <http://creativecommons.org/licenses/by-nc/4.0/legalcode> ;
      dct:source <http://creativecommons.org/licenses/by-nc/4.0/> ;
      dct:alternative "CC BY-NC" ;
      dct:hasVersion "4.0" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
      dct:publisher "Creative Commons" ;
      dct:title "Creative Commons - Attribution-NonCommercial 4.0 International
- CC BY-NC 4.0"@en ;
      odrl:permission
              [ odrl:action cc:Distribution ,
<http://purl.org/NET/ldr/ns#extraction> , cc:Reproduction , cc:DerivativeWorks ,
<http://purl.org/NET/ldr/ns#reutilization> ;
                odrl:duty
                        [ odrl:action cc:Notice , cc:Attribution
                        ]
              ] ;
      odrl:prohibition
              [ odrl:action cc:CommercialUse
              ] ;
      foaf:logo <http://i.creativecommons.org/l/by-nc/2.0/88x31.png> ;
```

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```
@prefix cc:      <http://creativecommons.org/ns#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix odrl:    <http://www.w3.org/ns/odrl/2/> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

<http://purl.org/NET/rdflicense/cc-by-sa2.0>
      a       odrl:Policy ;
      rdfs:label "Creative Commons CC-BY-SA" ;
      rdfs:seeAlso <http://creativecommons.org/licenses/by-sa/2.0/legalcode> ;
      dct:source <http://creativecommons.org/licenses/by-sa/2.0/> ;
      dct:hasVersion "2.0" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
      dct:publisher "Creative Commons" ;
      odrl:permission
              [ odrl:action cc:Distribution , cc:Reproduction ,
cc:DerivativeWorks ;
                odrl:duty
                        [ odrl:action cc:Notice , cc:ShareAlike , cc:Attribution
                        ]
              ] ;
```

Fig. 23: Código RDF de la licencia *Creative Commons CC-BY-SA 2.0*

B.3. Creative Commons CC_BY 3.0

Licencia

Código RDF

```
@prefix cc:      <http://creativecommons.org/ns#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix odrl:    <http://www.w3.org/ns/odrl/2/> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

<http://purl.org/NET/rdflicense/cc-by3.0>
      a       odrl:Policy ;
      rdfs:label "Creative Commons CC-BY" ;
      rdfs:seeAlso <http://creativecommons.org/licenses/by/3.0/legalcode> ;
      dct:hasVersion "3.0" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
      dct:source <http://creativecommons.org/licenses/by/3.0/> ;
      odrl:permission
              [ odrl:action cc:Distribution , cc:DerivativeWorks ,
cc:Reproduction ;
                odrl:duty
                        [ odrl:action cc:Notice , cc:Attribution
                        ]
              ] .
```

Fig. 24: Código RDF de la licencia *Creative Commons CC-BY 3.0*

B.4. GNU Public License 1.0

Licencia

Preamble

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c) If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the simplest and most usual way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this General Public License.

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Mere aggregation of another independent work with the Program (or its derivative) on a volume of a storage or distribution medium does not bring the other work under the scope of these terms.

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END OF TERMS AND CONDITIONS

Appendix: How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to humanity, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the çopyright"line and a pointer to where the full notice is found.

¡one line to give the program's name and a brief idea of what it does.¿Copyright (C) 19yy ¡name of author¿

This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 1, or (at your option) any later version.

This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.

You should have received a copy of the GNU General Public License along with this program; if not, write to the Free Software Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston MA 02110-1301 USA.

Also add information on how to contact you by electronic and paper mail.

If the program is interactive, make it output a short notice like this when it starts in an interactive mode:

Gnomovision version 69, Copyright (C) 19xx name of author Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type 'show w'. This is free software, and you are welcome to redistribute it under certain conditions; type 'show c' for details.

The hypothetical commands 'show w' and 'show c' should show the appropriate parts of the General Public License. Of course, the commands you use may be called something other than 'show w' and 'show c'; they could even be mouse-clicks or menu items–whatever suits your program.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a çopyright disclaimer"for the program, if necessary. Here a sample; alter the names:

Yoyodyne, Inc., hereby disclaims all copyright interest in the program 'Gnomovision' (a program to direct compilers to make passes at assemblers) written by James Hacker.

¡signature of Ty Coon¿, 1 April 1989 Ty Coon, President of Vice

That's all there is to it!

Código RDF

```
@prefix cc:      <http://creativecommons.org/ns#> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix owl:     <http://www.w3.org/2002/07/owl#> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix odrl:    <http://www.w3.org/ns/odrl/2/> .
@prefix foaf:    <http://xmlns.com/foaf/0.1/> .

<http://purl.org/NET/rdflicense/gpl1.0>
      a       odrl:Policy ;
      rdfs:label "GNU General Public License" ;
      rdfs:seeAlso <http://gnu.org/licenses/gpl-1.0.html> ;
      dct:source <http://gnu.org/licenses/gpl-1.0.html> ;
      dct:creator <http://fsf.org/> ;
      dct:hasVersion "1.0" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
      dct:publisher "Free Software Foundation" ;
      owl:sameAs <http://www.gnu.org/licenses/gpl-1.0.rdf> ;
      odrl:permission
              [ odrl:action cc:Distribution , cc:Reproduction ,
cc:DerivativeWorks ;
                odrl:duty
                        [ odrl:action cc:SourceCode , cc:Notice , cc:Copyleft
                        ]
              ] ;
      foaf:logo <http://www.gnu.org/graphics/gplv3-127x51.png> ;
```

Fig. 25: Código RDF de la licencia *GNU Public License 1.0*

B.5. BSD License Definition 2.0

Licencia

BSD License Definition

The BSD license is a class of extremely simple and very liberal licenses for computer software that was originally developed at the University of California at Berkeley (UCB). It was first used in 1980 for the Berkeley Source Distribution (BSD), also known as BSD UNIX, an enhanced version of the original UNIX operating system that was first written in 1969 by Ken Thompson at Bell Labs.

The only restrictions placed on users of software released under a typical BSD license are that if they redistribute such software in any form, with or without modification, they must include in the redistribution (1) the original copyright notice, (2) a list of two simple restrictions and (3) a disclaimer of liability. These restrictions can be summarized as (1) one should not claim that they wrote the software if they did not write it and (2) one should not sue the developer if the software does not function as expected or as desired. Some BSD licenses additionally include a clause that restricts the use of the name of the project (or the names of its contributors) for endorsing or promoting derivative works.

The most basic definition of a derivative work is a product that is based on, or incorporates, one or more already existing works. This can become a complex issue, particularly with regard to software, but the primary indicator that a software program is a derivative of another program is if it includes source code from the original program, even if the source code has been modified, including improving, extending, reordering or translating it into another programming language.

Source code is the version of software (usually an application program or an operating system) as it is originally written (i.e., typed into a computer) by a human in plain text (i.e., human readable alphanumeric characters). Source code can be written in any of hundreds of programming languages, some of the most popular of which are C, C++ and Java.

Due to the extremely minimal restrictions of BSD-style licenses, software released under such licenses can be freely modified and used in proprietary (i.e., commercial) software for which the source code is kept secret.

It is possible for a product to be distributed under a BSD-style license and for some other license to apply as well. This was, in fact, the case with very early versions of BSD UNIX, which included both new code written at UCB and code from the original versions of UNIX written at Bell Labs.

BSD-style licenses have been very successful, and they are now widely used for a variety of software. Among the many products released under this class of licenses are all of the major modern descendants of the original BSD UNIX, i.e., FreeBSD, OpenBSD, NetBSD and Darwin (the foundation of the Mac OS X). BSD-licensed software is also commonly included in Linux distributions (i.e., versions) and has even been incorporated into some of the Microsoft Windows operating systems.

BSD Licenses Versus the GPL

The GPL (GNU General Public License) is by far the most widely used license for free software (i.e., software whose source code is available at no cost for anyone to use for any purpose). The Linux kernel (i.e., the core of the operating system) as well as much of the other software generally included in Linux distributions have been released under the terms of the GPL.

Although far fewer programs are released under BSD-style licenses, this class of licenses is disproportionately important because of the widespread use of BSD-licensed code in both free and proprietary operating systems.

Possibly the biggest difference between the GPL and BSD licenses is the fact that the former is a copyleft license and the latter is not. Copyleft is the application of copyright law to permit the free creation of derivative works but requiring that such works be redistributable under the same terms (i.e., the same license) as the original work.

Closely related to this is the fact that, in sharp contrast to the GPL, BSD-style licenses do not require that derivative works based on BSD-licensed software make the source code for such derivative works freely available. This allows the direct incorporation of code from open source projects (i.e., from BSD-licensed software) into closed source projects. The GPL, however, specifically states: "This General Public License does not permit incorporating your program into proprietary programs."

A third difference is that the GPL is a single, copyrighted (by the Free Software Foundation, Inc.) license with no variants. BSD-style licenses, in contrast, are commonly modified for the specific situation.

In many cases, the use of open source code can allow companies to develop products more quickly and with less expense than if they wrote them with entirely original code. The fact that derivative products of BSD-licensed software are not required to be open source can be very useful for developers who want to create commercial products from open source code but who want to keep their modifications and/or extensions secret. Interestingly, companies that initially develop closed source products based on BSD-licensed code tend to be more likely to eventually make their source code publicly available than are companies that develop products that do not incorporate code code.

The issue of which license provides greater freedom and does the most to promote the development of improved software is highly controversial. In spite of the seeming simplicity of the licenses, there are no simple answers.

One of the most controversial properties of the GPL is its viral nature. This means that once some useful modification or addition to a GPL licensed program has been released, the source code of the modified or extended program must likewise be made freely available. That is, the GPL is a mechanism that deprives developers of the freedom to make their source code secret at some future date, although the developer can still use such code in commercial products. Critics of the GPL claim that this diminishes or destroys the commercial value of software because others can produce products that incorporate the same code.

GPL advocates claim that although the GPL is contagious in theory, it is not necessarily so in practice. Rather, they assert, it merely places restrictions on the code's re-use, as do BSD-style licenses.

One thing about both the GPL and the BSD-style licenses for which there is widespread agreement is that both have problems. Neither is perfect, and perhaps no license can be perfect. There is also considerable agreement that there are benefits both to software developers and to society as a whole from the choice provided by the existence of a variety of types of free software licenses, including the GPL and BSD-style licenses.

The .Advertising Clause"

The original version of the BSD license contained the so called advertising clause, which stated that all advertising materials that mention features of or use of the software must display the acknowledgment: "This product includes software developed by the University of California, Berkeley and its contributors."

One of the problems with this clause arose from the fact that people who made changes to the source code often wanted to have their names added to the acknowledgment. This could easily result in large and cumbersome acknowledgments for products with numerous contributors and for software distributions consisting of multiple individual projects.

A second problem was legal incompatibility with the terms of the GPL. This is because the GPL prohibits the addition of restrictions beyond those that it already imposes. Thus it was necessary to segregate GPL and BSD-licensed software within projects.

Initially, the .obnoxious BSD advertising clause,.as it was referred to by GPL advocates, was used only for the BSD UNIX license. That did not cause any major problems because it was only necessary to include a single sentence of acknowledgment in any advertisement.

However, the fact that other software developers did not copy the clause verbatim, but replaced the phrase Üniversity of California"with the name of their own organization or persons involved in it, resulted in a proliferation of slightly different licenses and a consequently serious problem when many such programs were assembled to form a larger work or an operating system. For example, if an operating system or other program required fifty slightly different acknowledgment sentences, each naming a different developer or group of developers, such advertising alone might require a full page. Not only would this be very tedious reading, but it could also be costly.

In June 1999, after two years of discussion, the Office of Technology Licensing at UCB finally proclaimed: .Effective immediately, licensees and distributors are no longer required to include the acknowledgment within advertising materials. Accordingly, the foregoing paragraph of those BSD Unix files containing it is hereby deleted in its entirety."

This was clearly very useful. However, it could not eliminate the legacy of the advertising clause, as similar clauses still exist in the licenses of many programs that followed the old BSD license; only the developers of such packages can change them.

Examples of BSD-Style Licenses

Below are three examples of BSD-style licenses: (1) the BSD license as it is used by the FreeBSD operating system, (2) a BSD license as it is used by Sudo (a free utility program for Unix-like operating systems) and (3) a template of a BSD-style license that can be applied to any appropriate project:

(1) The BSD license as it is used by the FreeBSD Unix operating system:

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Sudo is distributed under the following BSD-style license:

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Código RDF

```
@prefix cc:      <http://creativecommons.org/ns#> .
@prefix l4lod:   <http://ns.inria.fr/l4lod/> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix odrl:    <http://www.w3.org/ns/odrl/2/> .
@prefix owl:     <http://www.w3.org/2002/07/owl#> .

<http://purl.org/NET/rdflicense/BSD2.0>
      a       odrl:Policy ;
      owl:sameAs <https://licensedb.org/id/BSD-2-Clause> ;
      rdfs:label "2-clause BSD License" ;
      dct:source <http://www.linfo.org/bsdlicense.html> ;
      dct:hasVersion "2.0" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
      dct:publisher "The FreeBSD Project" ;
      odrl:permission
              [ odrl:action cc:Distribution , odrl:modify ;
                odrl:duty
                        [ odrl:action cc:Notice , cc:ShareAlike
                        ]
              ] ;
```

Fig. 26: Código RDF de la licencia *BSD License Definition 2.0*

B.6. IBM Public License 1.0

Licencia

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"Program"means the Original Program and Contributions.

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@prefix rdfs:     <http://www.w3.org/2000/01/rdf-schema#> .
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      a       odrl:Policy ;
      rdfs:label "IBM Public License" ;
      dct:source <http://opensource.org/licenses/IPL-1.0> ;
      dct:hasVersion "1.0" ;
      dct:language <http://www.lexvo.org/page/iso639-3/eng> ;
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              [ a       odrl:Duty ;
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      odrl:permission
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@prefix dct:     <http://purl.org/dc/terms/> .
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@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

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      a       odrl:Policy ;
      rdfs:label "MIT License" ;
      dct:source <http://opensource.org/licenses/MIT> ;
      dct:hasVersion "1.0" ;
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              [ odrl:action cc:Distribution , cc:DerivativeWorks ,
cc:Reproduction , odrl:modify , odrl:sell ;
                odrl:duty
                        [ odrl:action cc:Notice
                        ]
              ] ;
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      a       odrl:Policy ;
      rdfs:label "Eclipse Public License" ;
      dct:source <https://www.eclipse.org/legal/epl-v10.html> ;
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@prefix foaf: <http://xmlns.com/foaf/0.1/> .
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@prefix odrl: <http://www.w3.org/ns/odrl/2/> .
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@prefix dct:     <http://purl.org/dc/terms/> .
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                odrl:prohibition
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Fig. 40: Código RDF de la licencia *Creative Commons CC0 1.0*

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Código RDF

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              [ a       odrl:Prohibition ;
                odrl:action cc:Distribution
              ] ;
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