NIHR | Maudsley Biomedical Research Centre

Natural language processing: an introduction

Angus Roberts, Senior Lecturer in Health Informatics
Institute of Psychiatry, Psychology and Neuroscience
King’s College London

Contents

- Background and motivation
- Free text in administrative and service records
- Tackling text with Natural Language Processing (NLP)
- Information extraction
- Tools for the job
- Conclusion

Administrative and service records

- Throughout these presentations, we will consider NLP with reference to electronic health records – that’s what we are familiar with
- We suggest that the same ideas can be applied to other record types where there is use of free text

Background and motivation

Motivation – reusing records

- Thomas Willis in *Dr. Willis's Practice of Physick Being All the Medical Works of That Renowned and Famous Physician. 1684.*
  - **weigh all the symptoms, and to put them, with exact Diaries of the Diseases, into writing; then diligently to meditate on these, and to compare some with others; and then [begin] to adopt general Notions from particular Events**
- Reuse of the medical record
- Precursor of manual coding, enabling a more rigorous and larger scale of analysis
- Computerisation of the record allows us to magnify the efforts of Willis and of manual coding by many degrees

EHRs vs traditional studies

- Clinical cohort studies…

  expensive and time consuming, especially for rarer disorders, to recruit and follow enough people
- RCTs / experimental studies…

  Often cannot do these for ethical reasons
- Relapse of mental disorder…

  Lack of patient capacity to consent
- Allows us to include…

  Representative samples, patients who may not be able to take part in clinical studies – e.g. suicidal patients, very sick and marginalised

Free text in the electronic health record (EHR)

Structured data capture might not capture context

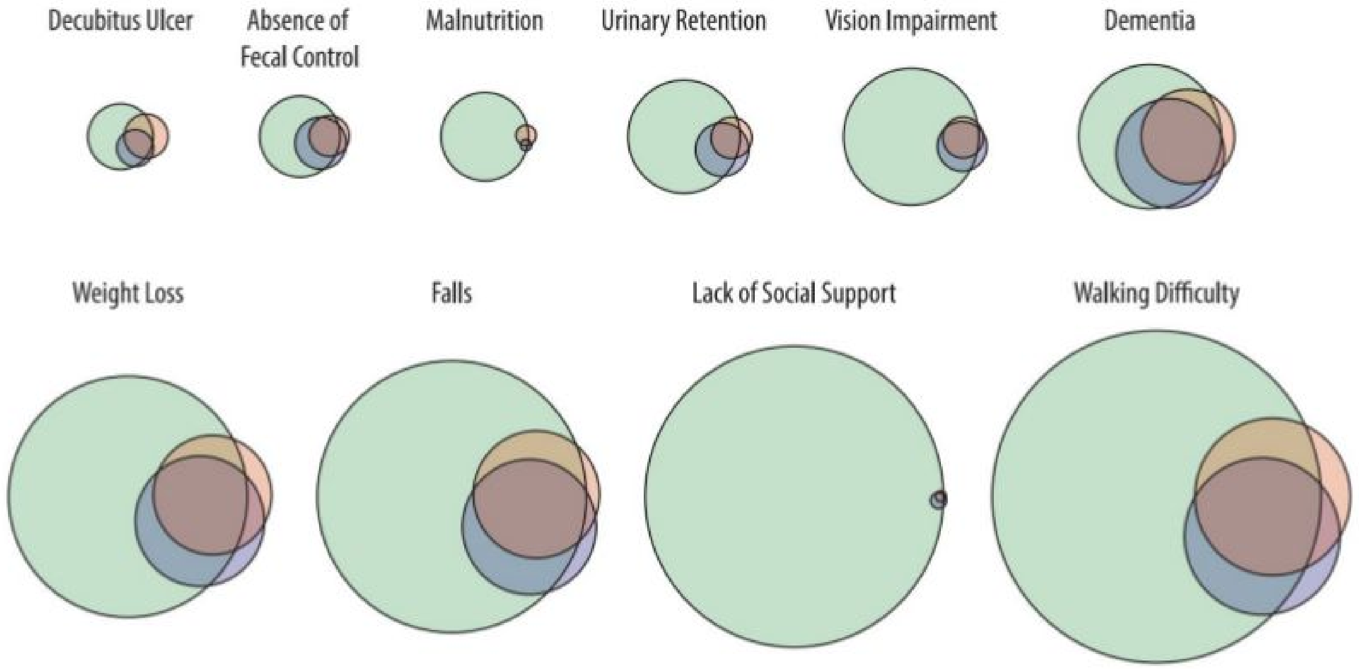
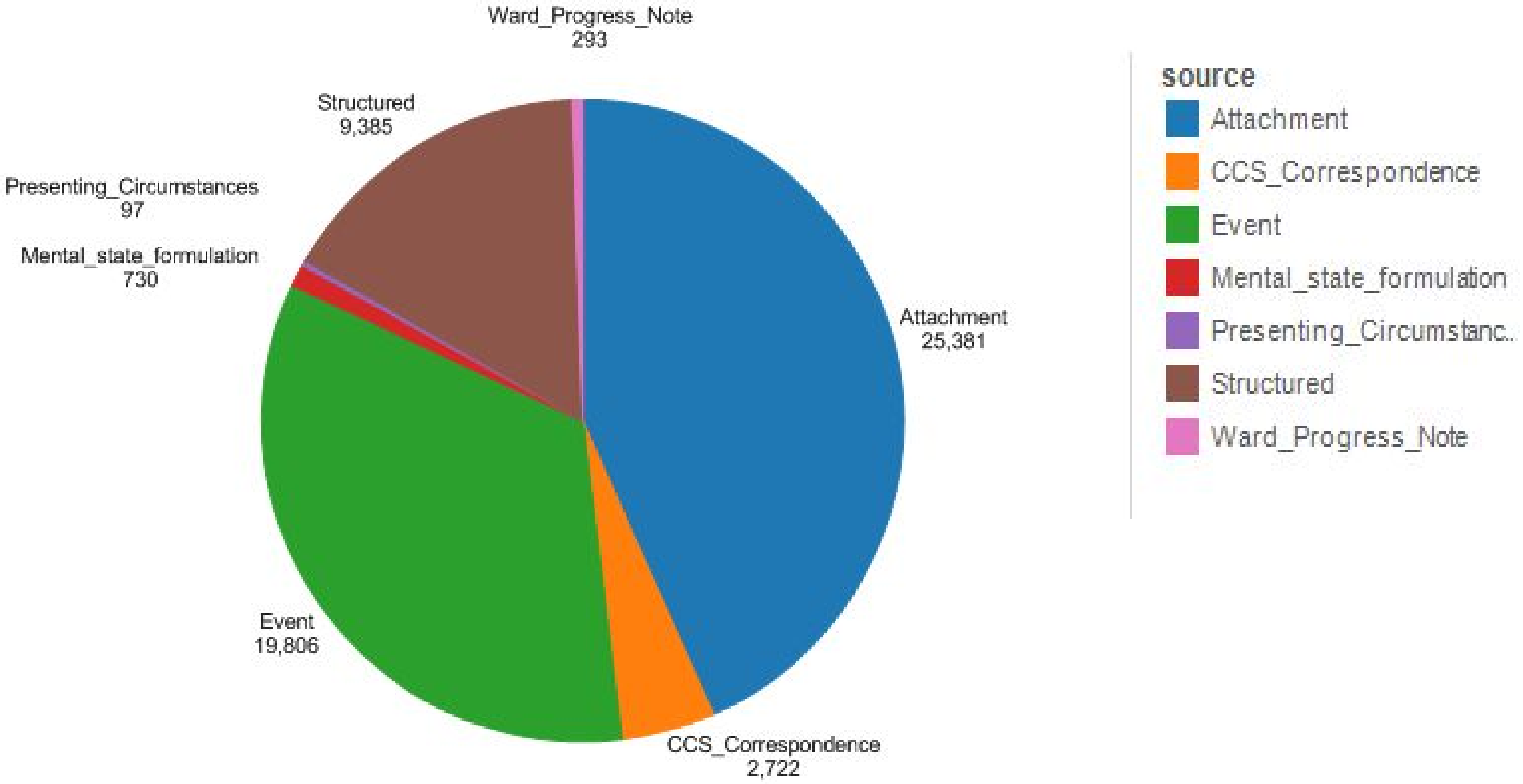


Figure 2. Green: Unstructured free text EHR data; Other colours: structured data. “The value of Unstructured Electronic Health Record Data in Geriatric Syndrome Case Identification”. (Kharrazi et al., 2018)

Structured data capture can be unpopular



Natural language: the **benefits**

- Flexible: capable of representing new and unusual cases
- Imprecision when facts are not known, when there is uncertainty, or when the author does not want to commit
- Elision and glossing of detail
- Expansive description of detail
- Lack of formal, prescriptive schema or data entry requirements
- Quick and easy data entry

Natural language: the **drawbacks**

- Flexible: capable of representing new and unusual cases
- Imprecision when facts are not known, when there is uncertainty, or when the author does not want to commit
- Elision and glossing of detail
- Expansive description of detail
- Lack of formal, prescriptive schema or data entry requirements
- Quick and easy data entry

Problems when analysing language

Ambiguity	- To some degree - Finishing her degree
Grammatical subject	- She smokes - Her mother smokes
Hedging	Probably a possible tumour
Negation	He no longer smokes
Synonymy, abbreviations, acronyms	MMSE, Mini Mental State Exam, Folstein
Extracting patterns	- 17th percentile - 5 weeks and 3 days
Relationships and events	His MMSE was 24/30 a week before the appointment

Natural language processing (NLP)

NLP origins

- 50s and 60s
  - Machine Translation
    - Russian – English
    - Hand coded rules and large dictionaries
- Late 60s to late 70s
  - Failure to deliver and cut in funding
- Mid 80s to mid 90s
  - Competitive challenges, e.g. Message Understanding Conferences
    - Organised by Naval Command, Control and Ocean Surveillance Center
    - Originally, extraction of information from military messages
    - Moved on to news reports on terrorist attacks, and trade union disputes…
    - Largely rule based systems

Natural Language Processing

- **a theoretically motivated range of computational techniques for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing for a range of tasks or applications**

  (Liddy, in Encyclopedia of Library and Information Science, 2nd edition, 2003. page 137)

Natural Language Processing

- **a theoretically motivated range of computational techniques for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing for a range of tasks or applications**

  (Liddy, in Encyclopedia of Library and Information Science, 2nd edition, 2003. page 137)

Natural Language Processing

- **a theoretically motivated range of computational techniques for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing for a range of tasks or applications**

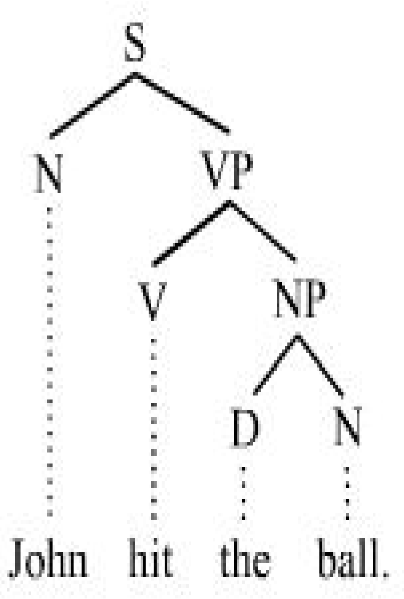
(Liddy, in Encyclopedia of Library and Information Science, 2nd edition, 2003. page 137)

Levels of linguistic analysis

Lexicon - the words

- A foul and pestilent congregation of vapours.
- 1.30pm: Cx: 3cm. Contractions q2-3 min. FHR: reassuring.

Syntax - the grammatical structure



Levels of linguistic analysis

Semantics - meaning

- Expression of atrial natriuretic factor gene in ventricular tissue
- BEHAB expression in ventricular tissue

Pragmatics - context

- I saw this 12 year old girl in clinic today with her mother. She is morbidly obese.

Levels of linguistic analysis

This lady attended outpatients today. In 1984 she had a right simple mastectomy of a carcinoma of the breast and was commenced on Tamoxifen. There was no sign of tumour recurrence on follow up.

Her new symptoms are of lymphoedema in the right arm which has developed over the last six weeks. She has also complained of pain in the right hip. I note her recent FBC was normal.

I have taken the precaution of doing an X-ray of the pelvis and given her a tubigrip bandage to use for the lymphoedema in her arm. We plan to see her again in two weeks time with the result of the X-ray.

Many applications...

- Search - information retrieval
- Information extraction
- Question answering
- Document summarisation
- Dialogue
- Machine translation
- Document classification
- Social media tracking
- ….

Information extraction

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

  (Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

  (Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

  (Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

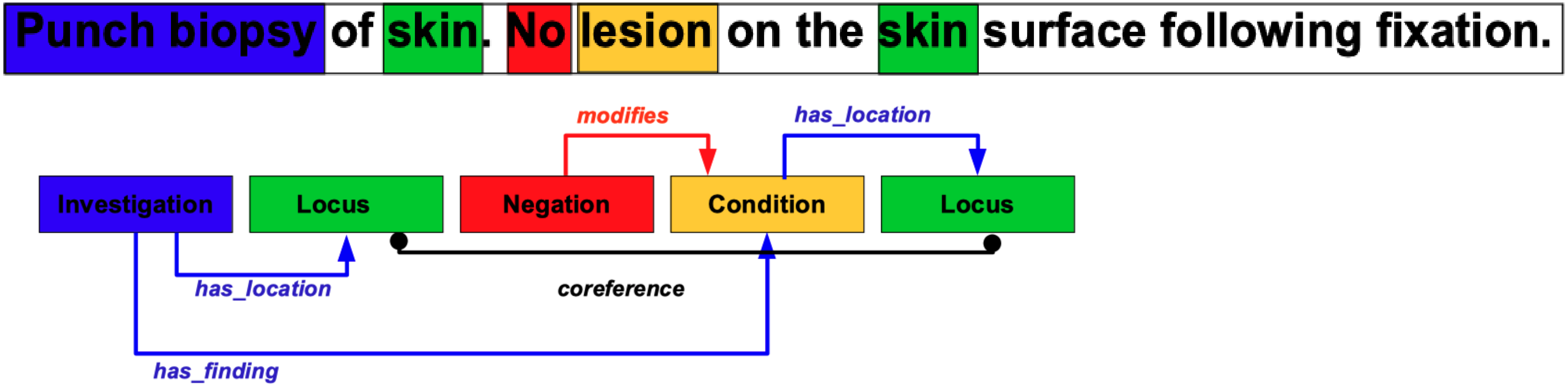
  (Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

(Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

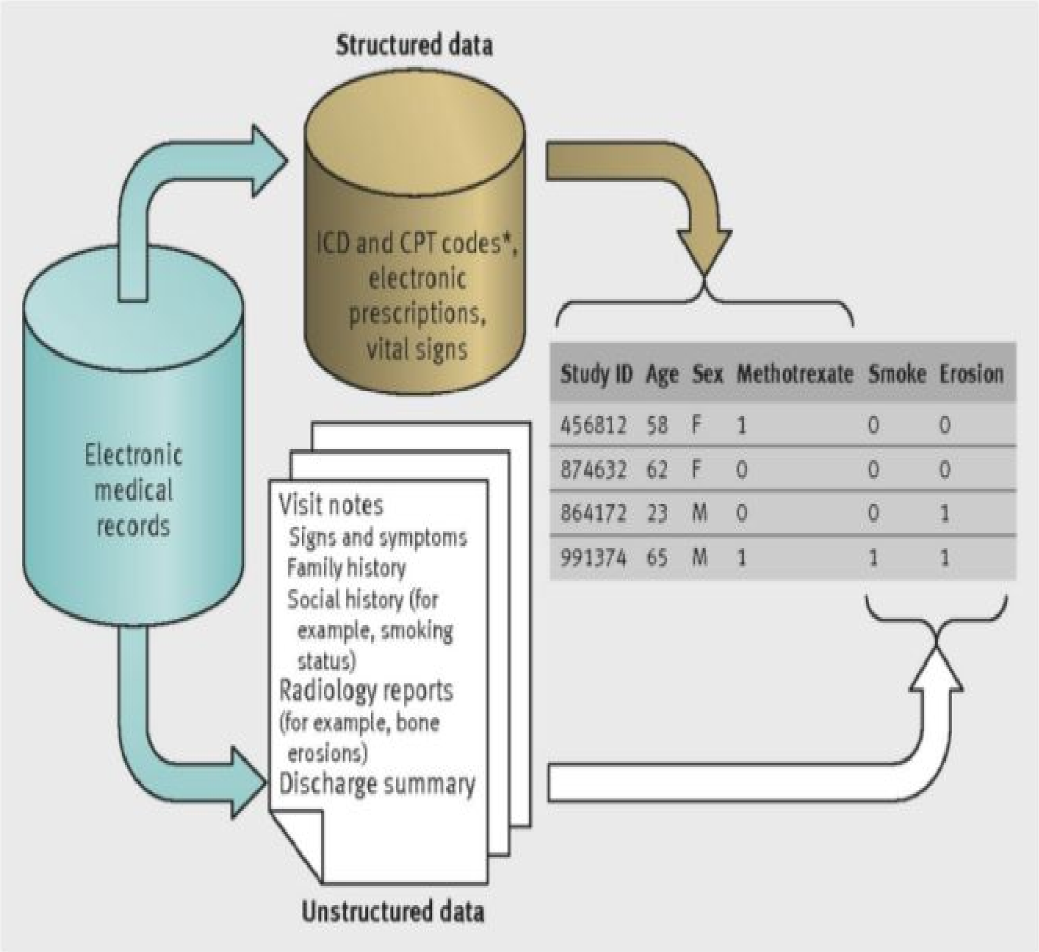
Information extraction



Punch biopsy of skin. No lesion on the skin surface following fixation.

- We might extract:
  - Entities and their co-referents
  - Negation, certainty, time
  - Relations
  - Events

Information extraction



Structured data

ICD and CPT codes*, electronic prescriptions, vital signs

Electronic medical records

Visit notes
- Signs and symptoms
- Family history
- Social history (for example, smoking status)

Radiology reports (for example, bone erosions)

Discharge summary

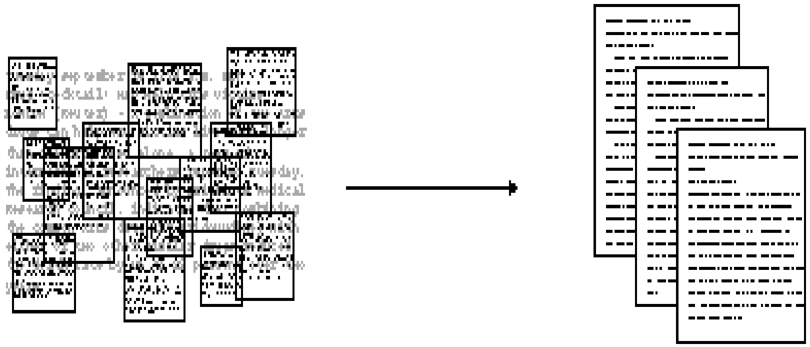
Unstructured data

Study ID	Age	Sex	Methotrexate	Smoke	Erosion
456812	58	F	1	0	0
874632	62	F	0	0	0
864172	23	M	0	0	1
991374	65	M	1	1	1

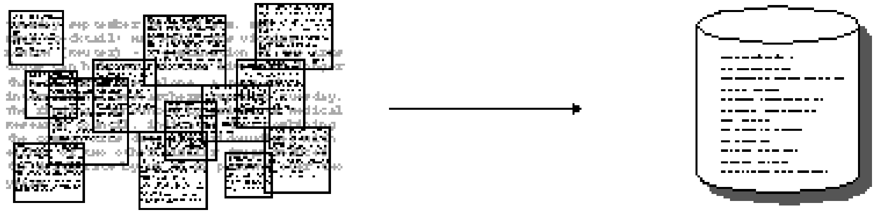
Liao et al. ***Development of phenotype algorithms using electronic medical records and incorporating natural language processing.*** *BMJ 2015;350:h1885*

Information extraction vs information retrieval

IR pulls **documents** from large text collections in response to specific keywords or queries. You analyse the **documents**.



IE pulls **facts** and **structured information** from the content of large text collections. You analyse the **facts**.



Tools for the job

GATE

- A widely used open source NLP toolkit, 20+ years old, 35 000+ downloads per year
- Graphical user interface
- Plug and play approach
- No programming skills required
- Large user community
- 100s of modules for all kinds of language processing tasks
- Scales to large distributed systems and data
- Limited support for state of the art NLP

GATE

Python

- Currently the most popular way of doing NLP
- Requires programming skills
- Most popular Python packages:
    - RE – python regular expressions
    - NLTK – general NLP and pre-processing
    - spaCy – “best of breed” statistical models
    - SciPy – lots of machine learning
    - Hugging Face – language models
    - TensorFlow – neural nets

Conclusion

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

  (Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

  (Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

Does the data exist in our records?

Information extraction

- **the process of deriving disambiguated quantifiable data from natural language texts in service of some pre-specified precise information need**

  (Cunningham, in Encyclopedia of Language and Linguistics, 2nd Edition, pages 665–677, 2005.).

Does the data exist in our records?

Can we define what we want to extract?

Thank you.
Any questions?

angus.roberts@kcl.ac.uk