What-You-Retrieve-Is-What-You-See: A Preliminary Cyber-Physical Search Engine

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1. EXTENDED ABSTRACT

The cyber-physical systems (CPS) are envisioned as a class of real-time systems integrating the computing, communication and storage facilities with monitoring and control of the physical world. One interesting CPS application in the mobile Internet is to provide Web search "on the spot" regarding the physical world that a user sees, or literally *WYRIWYS* (What-You-Retrieve-Is-What-You-See).

WYRIWYS cannot be readily addressed by the existing location-based Web search (abbreviated LWS onwards) [1, 2] due to the following reasons. First, LWS retrieves objects and computes the query/object relevance by combining their content relevancy and geometric proximity. Therefore it is unaware of the visibility of the physical entities of the Web objects to the user. Objects spatially close to the user may always be retrieved whether they are being monitored by the user or not. Second, the data management scheme of LWS typically integrates spatial indexes with an inverted index. Search service built on such scheme is likely to ignore crucial cyber-physical events, for example change of user orientation, which are considered as useful feedback cues for interaction with the CPS.

The objective of our work is to develop server/browser software to support WYRIWYS search in our prototype cyber-physical search engine. A WYRIWYS search retrieves visible Web objects and ranks them by their cyber-physical relevances (term, visual, spatial, temporal etc.). The search server contains three key components: (1) A database of Web objects, where each object is associated with a set of highly correlated Web documents. (2) A term-visibility indexer which indexes the Web objects by keywords and viewing regions. The indexer also maintains the quantitative measures of the visibility of the Web objects with regard to different viewing regions. Given a set of keywords and a view point in the physical space, the indexer is able to efficiently find the relevant visible Web objects. (3) A C-P rank module which ranks the objects by cyber-physical relevance including keyword relevancy, document authority, visibility, and the temporal urgency that a user physically visits the object.

(a) 3D mode (b) 2D mode (c) List mode

Figure 1: Browser Interface

The browser runs on an Android phone and can support queries in both the 3D and 2D modes. Each query is issued by specifying a set of keywords and a physical setting, including the position, the orientation, and the speed of the user. The 3D-mode results are embedded into a real-time camera image. This provides an immersive cyber-physical experience during the search. Figure 1(a) shows the 3D search results displayed in clusters where each cluster corresponds to a semantic Web object. The 2D-mode provides a bird's-eye view of the surroundings, as figure 1(b) shows. Web objects that the user sees are shaded in green circles while those invisible are in red.

This work is distinguished from previous LWS as it provides quality Web search geared with the physical world. Compared to the LWS provided by Google, our prototype provides a brand new *immersive search* service for what the user sees in physical space. Therefore it suggests a very promising solution to cyber-physical Web search.

2. ACKNOWLEDGMENTS

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3. REFERENCES

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