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DLtrace: Toward Understanding and Testing Deep Learning Information Flow in Deep Learning-Based Android Apps

Authors : Jie Zhang, Qianyu Guo, Tieyi Zhang, Zhiyong Feng, Xiaohong Li

Abstract : With the widespread popularity of mobile devices and the development of artificial intelligence (AI), deep learning (DL) has been extensively applied in Android apps. Compared with traditional Android apps (traditional apps), deep learning based Android apps (DL-based apps) need to use more third-party application programming interfaces (APIs) to complete complex DL inference tasks. However, existing methods (e.g., FlowDroid) for detecting sensitive information leakage in Android apps cannot be directly used to detect DL-based apps as they are difficult to detect third-party APIs. To solve this problem, we design DLtrace; a new static information flow analysis tool that can effectively recognize third-party APIs. With our proposed trace and detection algorithms, DLtrace can also efficiently detect privacy leaks caused by sensitive APIs in DL-based apps. Moreover, using DLtrace, we summarize the non-sequential characteristics of DL inference tasks in DL-based apps and the specific functionalities provided by DL models for such apps. We propose two formal definitions to deal with the common polymorphism and anonymous inner-class problems in the Android static analyzer. We conducted an empirical assessment with DLtrace on 208 popular DL-based apps in the wild and found that 26.0% of the apps suffered from sensitive information leakage. Furthermore, DLtrace has a more robust performance than FlowDroid in detecting and identifying third-party APIs. The experimental results demonstrate that DLtrace expands FlowDroid in understanding DL-based apps and detecting security issues therein.

Keywords : mobile computing, deep learning apps, sensitive information, static analysis
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